Opting for co-operation

Report of the
Siting Process Task Force
on Low-Level Radioactive
Waste Disposal

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SITING PROCESS
TASK FORCE
low level radioactive waste disposal

GROUPE DE TRAVAIL :
PROCESSUS DE LOCALISATION
élimination des déchets faiblement radioactifs

The Honourable Gerald S. Merrithew, P.C., M.P.
Minister of State (Forestry & Mines)
Ottawa

Dear Sir:

On December 11, 1986, you requested that we investigate and report on the most promising strategy for siting a low-level radioactive waste disposal facility in the Province of Ontario. In accordance with our mandate, we the undersigned members of this Siting Process Task Force are pleased to submit our report for your consideration.

Our investigation covered many issues. Some were directly relevant to the design of a less confrontational siting process. Others, while not directly related to process design, nonetheless constituted important issues which have contributed significantly to the ill-will that historically has hindered waste management facility siting initiatives. We were convinced that for the complexity of the radioactive waste management question to be fully appreciated, these side issues also needed to be discussed.

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538-580 BOOTH, OTTAWA, ONTARIO, K1A 0E4 (613) 995-8607/995-3866

We thank you for having given us this opportunity, and trust that our findings will support your efforts to bring a new, more co-operative spirit to the site selection process.

Yours respectfully,

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Co-ordinator

Audrey N. Armour

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Table of contents

Siting Process Task Force mandate ix

Executive summary xi

Chapter one: Introduction 1

1.1 The historical context 1
1.2 Task Force activities 3

The findings

Chapter two: The nature of radioactivity and radiation 7

2.1 Radioactivity 7
2.2 Radiation 8

Chapter three: Low-level radioactive waste 13

3.1 Waste production 13
3.2 Present classification of wastes 13
3.3 An alternative approach to the classification of wastes 14
3.4 Inventory of waste quantities 16
3.5 Conclusions and recommendations 22

Chapter four: Low-level radioactive waste management 23

4.1 Responsible management 23
4.2 Waste management concepts 25
4.3 Technical options for a waste management facility 27
4.4 The need for improved management 34
4.5 The need to reassess management options 38
4.6 Cost considerations 39
4.7 Conclusions and recommendations 43

Chapter five: Facility siting 45

5.1 Siting conflicts 45
5.2 Current approaches to facility siting 45
5.3 The "soft" issues 47
5.4 Conclusions and recommendations 50

Chapter six: Regulatory issues 53

6.1 The Atomic Energy Control Board and its role 53
6.2 Standards setting 53
6.3 Conclusions and recommendation 54

Chapter seven: Key features of the process 57

7.1 Principles 57
7.2 Safeguards 59
7.3 Impact management 61
7.4 Potential impacts on a volunteer community 63
7.5 Potential impacts on communities with existing wastes 65
7.6 Impacts on communities along transportation routes 66
7.7 Impact management strategy development 67
7.8 Organizational framework for implementation of the Process 67
7.9 Conclusions and recommendations 68

Chapter eight: Process description 69

8.1 Phase one: Establishing guidelines 70
8.2 Phase two: Regional information sessions 72
8.3 Phase three: Community information and consultation 75
8.4 Phase four: Project assessment 77
8.5 Phase five: Implementation 80
8.6 Timing 83
8.7 Implications of the Process and prerequisites for its implementation 83
8.8 Conclusions and recommendations 86

A final word 87

Appendices

A Prime Minister's letter to Port Hope area residents 93
B Low-level radioactive waste policy 97
C 1 Honourable Allan Lawrence's October 10, 1986 Port Hope announcement of the redirection of low-level waste disposal process 107
2 Honourable Gerald S. Merrithew's December 11, 1986 announcement of an independent Task Force 109
D Radiation, radioactivity and health 119
E Glossary of terms 127
F Task Force letter to DOE, MOE, NH&W, and AECB 133
G Response to Task Force letter 143
H Assumptions for the determination of transport cost estimates to move the low-level radioactive wastes out of the Port Hope area 167
I References identified by numbers in text 173
J Bibliography 177

List of figures

Figure A	Consultative site selection process	xiv
Figure 1	Port Hope area low-level radioactive waste sites	2
Figure 2	The electromagnetic energy spectrum	9
Figure 3	Ontario low-level radioactive waste accumulations	17
Figure 4	Current annual production of low-level radioactive waste in Ontario	19
Figure 5	Class 0 wastes in Ontario	21
Figure 6	LLRW resulting from nuclear energy and radioisotopes	21
Figure 7	Port Hope area low-level radioactive wastes	21
Figure 8	Illustration of an above-ground vault (Acres International Limited, 1987)	28
Figure 9	Illustration of a shallow land burial facility (engineered trench) (Acres International Limited, 1987)	29
Figure 10	Illustration of a below-ground vault after closure (Acres International Limited, 1987)	30
Figure 11	Illustration of a modular concrete canister disposal facility and canister (Acres International Limited, 1987)	31
Figure 12	Illustration of an augered hole low-level waste disposal facility (Acres International Limited, 1987)	31
Figure 13	Illustration of a conceptual mined cavern disposal facility (Acres International Limited, 1987)	33
Figure 14	Traditional facility siting process	46
Figure 15	Impact management strategy development	67
Figure 16	Consultative siting process	69
Figure 17	Phase one – Establishing guidelines	71
Figure 18	Phase two – Regional information sessions	73
Figure 19	Phase three – Community information and consultation	75
Figure 20	Phase four – Project assessment	78
Figure 21	Phase five – Implementation	81

List of tables

Table 1	An alternative approach to the classification of low-level radioactive wastes	15
Table 2	Summary of waste quantities	18
Table 3	Classification of Ontario's low-level radioactive waste (1985).	20
Table 4	A qualitative ranking of concepts for disposal of all Ontario's low-level waste.	27
Table 5	Waste management facility costs	40
Table 6	Comparison of transportation methods	42
Table 7	Summary of project costs	43
Table 8	General community profile check list	75
Table A	Uranium and thorium radioactive decay series	122

Siting Process Task Force mandate

The central focus of the Task Force's efforts was to be the development of a process for siting a disposal facility in Ontario for the existing, ongoing and historic wastes in the Port Hope area, and where advantageous, for the disposal of other existing and ongoing low-level wastes located in the province. The main objective of the process was to be the voluntary identification of one or more host communities, each with a suitable disposal technology.

To carry out this responsibility, the Task Force was to submit to the Minister of State (Forestry and Mines) a report which would, at a minimum:

- describe and analyze the processes which have been used to site controversial facilities in other jurisdictions nationally and internationally;
- describe a recommended process for this project and explain how it is intended to meet the overall objective;
- define what is meant by a host community, identify techniques which can be used to measure the level of acceptance by the public of such a proposal in a community, and recommend the criteria to be applied to determine the degree of acceptance;
- address the economic framework for community discussions, and identify costs, benefits and opportunities associated with facility siting. An attempt was to be made to address the nature and quantification of appropriate levels of economic offsets that might need to be associated with such a facility;
- examine and comment on the possible constraints or implications on site selection such as population density, land use, and water resources;
- examine and comment on the possible constraints or implications of transportation to remote sites and the positive and negative consequences of more than one disposal facility in the province;
- identify the existing policies, legislation and regulations related to the management of low-level radioactive wastes, and list the government agencies responsible. Comment on possible implications for or changes to the policies, legislation, or regulations which may be necessary to assist in facility siting;
- present a communications plan and the introductory communications module which will allow for the implementation of the next stage of the recommended process; and
- recommend an organizational structure, identify opportunities for public involvement, and suggest responsibilities for design and construction in later phases of the siting process.

In order to understand the nature of the problem, the Task Force, by reviewing existing information and augmenting it as necessary, was to:

- identify the nature and quantities of wastes in the Port Hope area and other sources of wastes in the province;
- identify the most promising available technologies for low-level radioactive waste disposal and indicate constraints relative to each one;
- for various geological settings within the province, identify which of the above technologies are most suitable;
- for each technology which can be used in Ontario, identify the associated economics, including estimates of the capital cost of construction and operation, as well as employment opportunities; and
- for each region of the province, identify the cost of transporting wastes by whatever modes are reasonably available from the Port Hope area to a hypothetical disposal facility in that region. In addition, analyze the health, safety and environmental risks for each transportation option.

Executive summary

Low-level radioactive wastes have been accumulating in Ontario for decades, and continue to do so. They are found not only in the Port Hope area, which was the raison d'être for this Report, but also elsewhere in the province, as well as in other parts of Canada.

In the absence of universally applied and respected procedures for handling such wastes, there has developed in the public mind a strong mistrust of, and hostility toward, waste producers and regulatory agencies. In such a climate, it is not surprising that attempts to site facilities for the management of low-level radioactive wastes have been met with antagonism. Indeed, the problems of siting contentious facilities are not limited to low-level radioactive wastes. In this particular case, however, because the labels of radiation and radioactivity are attached, problems are compounded by a perception of risk which, while it may sometimes be exaggerated, is widely and sincerely held.

Attempts have been made to take appropriate action to alleviate the threats which these wastes may pose to human health or the environment. However, these efforts have been hampered, if not effectively destroyed, by the adversarial response engendered by current facility-siting processes. On the one side stand those charged with finding a solution to burgeoning problems of waste management, prepared with their rational, technical solutions, looking to employ them in the most environmentally appropriate site. On the other side stand the potentially affected communities and residents with their concerns – their perceptions of risk, their view of inequities in the distribution of social and personal costs and benefits, their awareness of the community stigma that accompanies the unwanted facility, their feeling of loss of control over the quality of their lives and community, and their lack of trust in government regulators and waste facility operators. Neither side fully appreciates the needs, concerns, responsibilities or situation of the other; both perceive their position as eminently reasonable and responsible. In the case of low-level radioactive wastes, all these conflicts are particularly intense.

Traditional Canadian practice assigns responsibility for the management of low-level radioactive wastes to the waste producers and the regulators. This situation leaves those communities in which low-level radioactive wastes are located feeling powerless, without the means or authority to improve management. Excluding local communities from th discussion of low-level radioactive waste management leads them to see themselves as helpless victims of imposed decisions.

Disregard for community concerns has not been the only obstacle to effective action on low-level radioactive wastes. A second major factor has been the declared preference of the Atomic Energy Control Board (AECB) for the concept of permanent disposal as the ultimate acceptable means of handling low-level radioactive wastes. As the federal regulatory agency responsible for the safe management of many radioactive materials, the AECB has thus limited the possibilities for action. Permanent disposal means sequestering the wastes, until they have decayed to a safe level, away from the environment in a permanent facility requiring no monitoring, maintenance, or ongoing institutional controls. However, this concept is not necessarily endorsed by all the scientific community, and there is a great deal of skepticism and opposition to it on the part of the general public. One unfortunate aspect of the Board's adherence to this idea is the inhibiting effect it has on the search for simpler solutions, such as long-term storage, that concentrate on improved management of the wastes.

We believe that by specifically addressing the problems identified above, it is possible to overcome them and proceed to solutions – most notably to a siting process characterized by co-operation rather than conflict. The principles which are the foundation of the siting process proposed in this report are:

- The community should volunteer and have the right to opt out of the siting process at any time, rather than being selected by the project sponsor at its discretion.
- The community should be a partner in problem-solving and decision-making throughout the siting process.
- The community should receive compensation to offset unmitigable impacts and to enhance local benefits.

- The community should have the right to select from given technical options and impact management measures, the ones that are acceptable to it.
- The Siting Task Force responsible for the implementation of the Process must ensure that the safety of the environment and human health are not compromised for any reason.

Our first recommendations, therefore, concern the siting process itself. They are predicated on the assumption that, for at least part of the accumulated wastes, the preferred management option will involve removal of a substantial volume of the wastes to a newly-constructed facility at a distance from their present location. In this context, we recommend that:

- Voluntary acceptance be adopted as the basic procedural principle for the process of siting a low-level radioactive waste management facility.
- The emphasis given to technical assessments of management options and their potential impacts be counterbalanced by legitimization of an active, joint decision-making role for potentially affected residents who should be regarded as full partners in the process.
- The community accepting the facility be compensated in a way that offsets all costs and leaves the community better off than it was previously, as an acknowledgement of the service the community is providing.

We further recommend that, rather than permanent disposal, the concepts of improved management and long-term storage, with the ability to monitor and retrieve wastes, become the immediate objectives for the handling of low-level radioactive waste accumulations. Management options for each existing site should be determined on the basis of site-specific requirements and the wishes of the surrounding community. This approach encourages prompt action, rather than deferring management improvements in the hope that someday the ultimate "permanent" solution will present itself.

In addition to difficulties created by the technical-rational decision process and the permanent disposal approach, the current classification of low-level radioactive wastes also hinders efforts to gain public understanding of both the problems and potential solutions for waste management. Preliminary work by the Task Force indicates that it is feasible to establish and use an improved classification system based on the fundamental properties of the wastes and their associated management requirements rather than on their origins and administrative affiliations. We have devised a four-part classification system and recommend that the federal government use it as a basis for a more detailed technical study of such a system to be incorporated into future low-level radioactive waste management considerations.

We also believe that public understanding and public confidence will be enhanced if the AECB assumes a more proactive and prominent role in defining and establishing what are acceptable approaches to low-level radioactive waste management. Such a role should include the establishment of a set of explicit, detailed safety standards that could be applied consistently to all of its licencees. Furthermore, in conjunction with any action to improve management at existing sites, the AECB should provide to surrounding communities a definitive statement certifying that the waste management activity undertaken is effective and ensures adequate protection of the residents.

In the course of our work, we did not discover any generally agreed upon evidence that there is a serious current threat to human health or the environment from existing low-level waste accumulations in Ontario. This was in spite of specific inquiries made to agencies of the federal and provincial governments whose responsibilities lie in these areas. The finding may come as a surprise, since it is often assumed that the dominant imperative for "cleanup" or any other form of improved management is found in the need to protect health or the environment. It should, however, be pointed out that the experts (in this case, the AECB) are properly concerned that wastes which may not pose a threat to health or the environment at present may pose a threat at some future time because of breakdown in physical containment or a lapse in management. Furthermore, the AECB also accepts that there are reasons, other than health and environmental concerns, to have responsible and secure management.

As part of the Task Force's study of the inventory of existing and future low-level radioactive wastes and the efforts to construct an improved classification system for these wastes, we became aware that Carbon 14, a major component of some CANDU wastes, may pose special problems. As a result, we recommend that research into the waste management requirements of Carbon 14 be undertaken on an urgent basis.

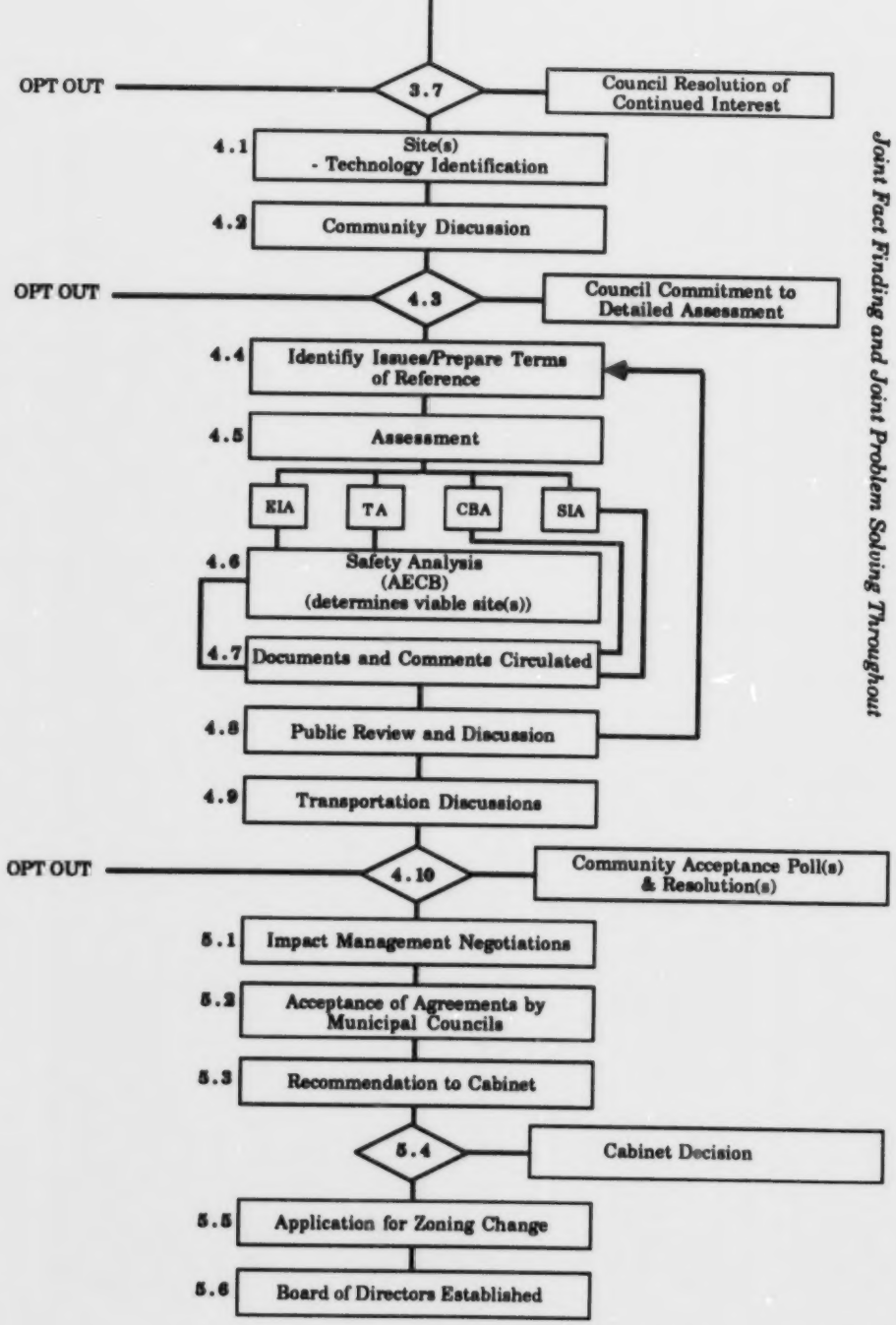
In light of our investigations, study and analysis of the low-level radioactive waste problems, and on the basis of our firm conviction that the conflicts and problems of siting waste facilities can be solved, we recommend that:

- The five-phase Process as outlined in Figure A be adopted as proposed, and be implemented so that its underlying principles are upheld and its safeguards applied. (It should be noted that, as with all complex diagrams, this process looks daunting when first viewed as a whole. It is, however, far less formidable when approached phase by phase.)
- In adopting the Process designed, Cabinet commence an investigation of the need for and feasibility of changes in the roles and responsibilities of government experts and regulators falling within federal jurisdiction and that their provincial counterparts be encouraged to do likewise.
- Cabinet authorize the initiation of plans of action to determine the waste management requirements of all communities currently housing low-level radioactive waste repositories. Further, such action plans should be carried out jointly by an independent group (with members to be selected by the federal government or one of its agencies) and representatives of the communities in question. Together they assess the extent of any management problems and devise solutions to the problems identified.

Figure A

Consultative site selection process

6 Months
2 - 6 Months
6 - 12 Months
PHASE 1
Establishing Guidelines
Cabinet Decision
Siting Task Force Established
1.1 Independent Expert Review of Background Report
1.2 Public Review of Background Reports
1.3 Draft Guidelines
1.4 STF Holds Public Meetings
1.5 Basic Guidelines
PHASE 2
Regional Information Sessions
2.1 Regional Profiles
2.2 Regional Sessions (technical options & requirements)
2.3 Letter Inviting Indication of Interest
OPT OUT
3.4
Expression of Continuing Interest
PHASE 3
Community Information and Consultation
3.1 Profile Interested Community/ies
3.2 Information Sessions (models, video, display, photos, process - formal authority, contacts -
3.3 Report to Council
OPT OUT
3.4
Expression of Continuing Interest
3.5 Community Liaison Group formed by Council and Task Force (broad community-base)
3.6 Consultation & Information Sessions (community at large)
(scale of project, address concerns, explain process, technology options, possible benefits)


OPT OUT
3.7
Council Resolution of Continued Interest
PHASE 4
Project Assessment
4.1
Site(s)
- Technology Identification
4.2
Community Discussion
OPT OUT
4.3
Council Commitment to Detailed Assessment
4.4
Identifiy Issues/Prepare Terms of Reference
4.5
Assessment
EIA
TA
CBA
SIA
4.6
Safety Analysis
(AECB)
(determines viable site(s))
4.7
Documents and Comments Circulated
4.8
Public Review and Discussion
4.9
Transportation Discussions
OPT OUT
4.10
Community Acceptance Poll(s) & Resolution(s)
PHASE 5
Implementation
5.1
Impact Management Negotiations
5.2
Acceptance of Agreements by Municipal Councils
5.3
Recommendation to Cabinet
5.4
Cabinet Decision
5.5
Application for Zoning Change
5.6
Board of Directors Established
Joint Fact Finding and Joint Problem Solving Throughout
18 - 24 Months
6 - 9 Months

Chapter one
Introduction

1.1 The historical context

A refinery, initially set up by the precursor of the present Eldorado Resources Limited (Eldorado) to recover radium, and subsequently uranium, has generated low-level radioactive waste in Port Hope since 1932. In the early years, municipal landfill sites and vacant land within the town were used to dispose of the refinery wastes.

Since 1948, Eldorado has placed its wastes on sites which it owns. In 1955, its first site, the Welcome site, was closed by the company following arsenic contamination of a pasture and a stream adjacent to its property. To avoid a repetition of this problem, Eldorado selected a site on the bluffs above Lake Ontario near the hamlet of Port Granby. Since then, wastes from the Port Hope plant have been buried at the Port Granby site (Figure 1).

Eldorado Resources plant at Port Hope, Ontario

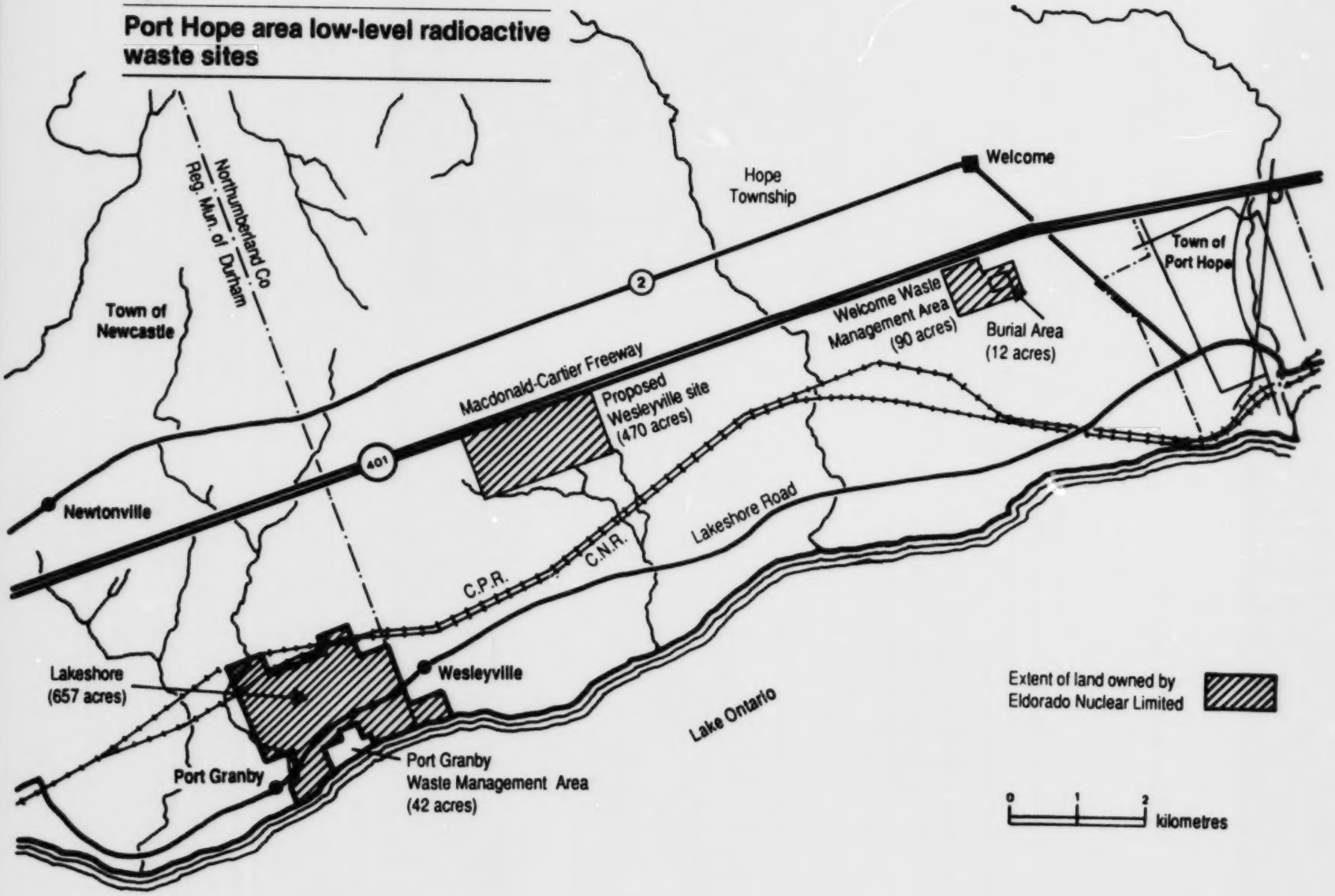
The Atomic Energy Control Board (the AECB or the Board) was not involved in these events because it did not begin licensing low-level radioactive waste management facilities until 1975. In that year, it issued the first operating licence for Port Granby.[1] In the licence issued in January 1977, the Board specifically referred to plans to control ground and surface water at the site and to other remedial work, including a water treatment facility, to help control the leachate from the site.[2] In 1979, the Board licensed the then inactive facility at Welcome and gave Eldorado instructions for remedial action at that site.[3]

In 1980, the Board directed Eldorado to present, by the end of 1986, plans for the decommissioning of the Port Granby low-level radioactive waste management facility.[4] This directive was given because of the Board's concern for the long-term stability of the bluffs which were eroding, a situation that would ultimately result in the wastes slipping into Lake Ontario. Eldorado commenced engineering and feasibility studies on locating a single waste disposal facility in the Port Hope area that would accommodate about 660,000 cubic metres of wastes and contaminated soils from both Port Granby and Welcome. As shown in Figure 1, the initial sites studied were Port Granby, Lakeshore and Wesleyville.

In 1982, the Low-Level Radioactive Waste Management Office of Atomic Energy of Canada Limited (AECL) was formed at the direction of the Minister of Energy, Mines and Resources. Its mandate includes responsibility for the cleanup and disposal of pre-1948 wastes in the town of Port Hope. These wastes were to be added to the proposed Eldorado disposal facility, bringing the total estimated volume of wastes and soils to be handled to 880,000 cubic metres.

Figure 1

Port Hope area low-level radioactive waste sites



During the federal election campaign of 1984, the siting of this proposed facility became an issue. The Right Honourable Brian Mulroney, then the Leader of the Opposition, wrote a letter in August of that year to an individual in Port Hope in which he stated that, " . . . there is ample evidence that neither of the current proposals by Eldorado Resources Limited for establishing a permanent radioactive waste disposal dump either near Port Granby or near Wesleyville are acceptable to the people of those communities or to their elected representatives. All such wastes should be removed from major population areas and kept well away from any major water resource such as Lake Ontario. While this would involve greater expense, the federal government, as owner of Eldorado Resources Limited, must accept at least partial responsibility and provide the leadership." (See Appendix A for the full text of this letter.) This letter raised the hopes of the local residents that the wastes in their area would be moved well away.

Considerable work was done on the development of the proposal to move the wastes. On April 25, 1986, the Honourable Robert E.J. Layton, the federal Minister of State (Mines), formally released the federal policy on low-level radioactive waste management (Appendix B) and announced his plans to refer the Port Hope area cleanup proposals of Eldorado and AECL to a formal environmental review. Under this policy, low-level radioactive waste would be dealt with in such a way that human health and the environment would be protected now and in the future, and that social and economic factors would be taken into account. The policy also detailed a series of corollaries on siting and licensing aspects and on the division of responsibilities between the producers of the wastes and the federal government. Mr. Layton also announced that Eldorado would drop from consideration two of the three sites originally proposed for the disposal facility, namely Port Granby and Lakeshore, and would seek another site further from Lake Ontario.

In June 1986, the Honourable Tom McMillan, federal Minister of the Environment, announced the membership of an environmental assessment panel to publicly review Eldorado's plans along with those of AECL's Low-Level Radioactive Waste Management Office for the cleanup and disposal of low-level radioactive wastes and soils stored in the Port Hope area.

In August 1986, Eldorado announced that it had taken options on two properties in the Port Hope area, one near Starkville and the other near Tyrone, both located more than ten kilometers from Lake Ontario. Eldorado planned to do surficial geological assessment on both sites before selecting one of them to accompany its Wesleyville site in the environmental assessment hearings. Because it was not considered critical that the final site be identified prior to issue identification (scoping) meetings, the Environmental Assessment Panel began its preparations for those hearings. However, the people living near both tracts of land were very upset over the fact that Eldorado was considering their areas for its waste facility. Their opposition was so vehement that, following discussion between all the affected federal departments and agencies, the decision was made to postpone the scoping meetings until after the final site selection had been made.

When this selection occurred in late September, public concern did not subside. As a consequence, federal departments and agencies involved with this subject were again forced to reconsider the issue. They concluded that the process being used for site selection was faulty. Furthermore, because of the ill-will generated in the Port Hope area, the decision was made to widen the geographic area to be searched as well as change the siting process itself.

On October 10, 1986, the Honourable Gerald S. Merrithew, federal Minister of State (Forestry and Mines), announced that he had requested a postponement of the Environmental Assessment Panel review of the Port Hope area low-level radioactive waste management issue (see Appendix C). At the same time, he announced that Eldorado would be requested to stop assessment work on the two sites identified as candidates for a permanent low-level radioactive waste disposal facility in the Port Hope area. Finally, Mr. Merrithew announced that he was forming a task force to advise him on an alternate, less confrontational site selection process that would not set communities and facility proponents against each other. This Task Force was given six to eight months to assess the most suitable technologies for low-level radioactive waste disposal, the areas with the best potential in the province to use these technologies and the most promising approaches to site selection.[5]

On December 11, 1986, Mr. Merrithew announced the appointment of the seven members to the independent Siting Process Task Force (see Appendix C).

1.2 Task Force activities

The Task Force began work in January 1987 with its analysis of the technical issues associated with low-level radioactive waste management and facility siting. Presentations were received from the AECB, AECL, Eldorado, and Energy, Mines and Resources.

Next, the Task Force conducted an extensive literature review of low-level radioactive issues and management programs, with special attention to the evolving low-level radioactive waste management situation in the United States. In addition, it commissioned three technical studies which are available as companion documents to this report. These studies respectively examine the low-level radioactive wastes situation in Ontario, the relative merits of various modern waste management technologies and approaches, and the issues and costs related to the transportation of this type of waste.[6,7,8] During the period January – April 1987, the Task Force visited the low-level radioactive waste management facilities at the Bruce Nuclear Power Development, the Chalk River Nuclear Laboratory, Port Granby, Welcome and a U.S. facility in Barnwell, South Carolina. It also undertook extensive examinations of the waste sites in Port Hope.

To understand the problems and issues involved in the siting process from the proponent's point of view, Task Force members held a series of round-table discussions with representatives from key organizations associated with other siting processes, including the Ontario Waste Management Corporation, the Alberta Special Waste Management Corporation, the Manitoba Department of the Environment and Ontario Hydro.

Throughout its work, the Task Force recognized that social and political issues involved in siting activities can be pivotal and are often more difficult to resolve than technical issues. For this reason, members made it one of their primary objectives to better understand the perspectives of those concerned with or affected by siting processes. In this regard, representatives of national and provincial public interest groups were invited to meet with the Task Force and share, in an informal round-table discussion, their past experiences and insights concerning needed improvements. To gain an impression of the perspectives of local residents, community groups, municipal councils and others who had been most directly affected by siting attempts and successes, the Task Force visited a number of communities including Swan Hills and Riley in Alberta; and Moore Township, the City of Mississauga, the Town of Newcastle, Hope Township, the Regional Municipality of Durham and the Town of Port Hope in Ontario. As a final consultation element in its work, the Task Force organized and hosted two workshops involving people with extensive experience in various stages of facility siting processes. Participants at the first workshop included national, provincial, and local interest group representatives as well as experts from the academic field, industry and government. They were asked to consider a number of items: problems with current processes of facility siting; the key elements of an acceptable siting process; communication mechanisms; the identity, roles and responsibilities of stakeholders in the siting process; means of assessing public acceptance of the process; and cost/benefit inequities.[9] The second workshop focussed specifically on the issues of impact management. People with expertise in this area were invited to provide comments on the nature of, and limits and appropriate approaches to, impact management.

A Facility Siting Workshop session.

In addition to consultation, the Task Force carried out an extensive review of research into the dynamics of siting conflicts, the public perception of risk, the public's attitudes toward waste management and the effectiveness of various impact management measures in reducing siting conflicts. As a result of these activities, Task Force members came to appreciate the multi-faceted nature of the facility-siting process and, in particular, the urgent need to redesign it. However, as revealed by the findings which are presented in the next part of this report, the issues involved in the process of siting a low-level radioactive waste management facility cannot be effectively addressed without an understanding of low-level radioactive wastes, current waste management practices, facility siting approaches in general, and the regulatory process.

This report is the culmination of the Task Force's efforts to deal with the complex and controversial issues so clearly evidenced by the context of events that led to the creation of the Task Force and its subsequent work. It is this context of social, political, economic, environmental, safety and other demands which has focussed the efforts of the Task Force in its work to design and recommend an effective and acceptable siting process for a low-level radioactive waste facility.

The findings

The redesign of the siting process, as called for in the Task Force mandate, demanded a careful assessment of the quantities and characteristics of low-level radioactive wastes, the current approaches to the management of such wastes, the nature of facility siting conflicts, and the administrative and regulatory procedures guiding the siting process.

The first challenge facing the Task Force was to understand fully why the siting of a low-level radioactive waste management facility is so problem-ridden. This part of the report presents the findings on this issue, starting from a consideration of pertinent aspects of radioactivity and radiation, as outlined in Chapter 2. Specific findings related to facility siting problems are set out in the four succeeding chapters, entitled *Low-level radioactive waste; Low-level radioactive waste management; Facility siting*; and *Regulatory issues*. In each of these areas, the Task Force reached several important conclusions which influenced its approach to the redesign of the facility siting process. Furthermore, in some of these areas, members saw a need to recommend specific actions essential to the implementation of their new siting process. Such conclusions and recommendations are set out at the end of each chapter.

Chapter two
The nature of radioactivity and radiation

The concerns of the public about low-level radioactive wastes are generally based on perceived threats posed to human health or the environment. Accordingly, responsible management of low-level radioactive waste requires appropriate measures to deal with its physical and chemical properties. In order for the Siting Process Task Force to fulfil its mandate knowledgeably, members investigated the fields of radiation and radioactivity as they apply to facility siting and concerns. The following descriptions of the nature of radioactivity and radiation present fundamental information necessary in assessing the issues involved. Additional information on the subject is provided in Appendix D, in the Glossary of Terms (Appendix E) and, as appropriate, throughout the text.

2.1 Radioactivity

The nuclei of certain atoms are, by their nature, unstable and liable to undergo spontaneous disintegration resulting in the emission of energy. This process is known as radioactive decay. Unstable atoms are termed "radionuclides." Each of the more than 1,800 known radionuclides has a unique characteristic rate of decay expressed as its "half-life," the time it takes for half the atoms initially present to decay. After two half-life intervals only one quarter of the original atoms remain to decay; after three half-life intervals only one eighth remain, and so forth. The half-life of radionuclides ranges from microseconds to billions of years.

Radionuclides have been present in nature and widely distributed on earth since its creation. Naturally occurring minerals contain small proportions of radionuclides. For example, 0.012 percent of the world's potassium is in the form of radioactive Potassium 40. This proportion is invariable, regardless of the source of the potassium. Thus, the potassium within the bodies of all living things, including human beings, is slightly radioactive; it constantly gives off gamma rays that irradiate the tissues of all beings.

Radioactive Carbon 14 is continuously produced in the upper atmosphere by the action of cosmic rays on non-radioactive Nitrogen 14. As part of the gas carbon dioxide, Carbon 14 is freely diffused through the atmosphere. Eventually, a small proportion becomes incorporated into the tissues of all living organisms. All living matter contains approximately one atom of Carbon 14 in every trillion stable atoms of carbon. The Carbon 14 decays very slowly; it has a half-life of 5,700 years. By measuring the proportion of radioactive to stable carbon, the point in time at which the incorporation of radioactive carbon ceased (i.e., the point of death) can be calculated. This carbon-dating process, as it is called, can be used to determine the age of anything derived from living matter as, for example, the age of wooden artifacts.

Like radioactive carbon, Tritium, a radioactive form of hydrogen, is constantly being formed as a result of cosmic ray action on the upper atmosphere. It too is dispersed around the globe. For example, all rainwater contains detectable amounts of Tritium. Measurements in 1951 and 1953 showed that Canadian rain and snow samples then contained approximately 40 Tritium atoms per 10^{18} hydrogen atoms. Similar measurement of the Tritium content in underground water allows calculation of the elapsed time since the water fell as rain. This is a standard hydro-geological technique that takes advantage of naturally occurring radioactivity. This specific technique is of particular relevance to radioactive waste storage because it is one of several techniques using radioactive tracers that could be employed in analyzing the groundwater of a potential site for a low-level radioactive waste management facility.

Uranium is a naturally occurring radioactive element that is also widely distributed on earth. Throughout the decay of uranium, a cascade of different radionuclides (a decay series) is formed until stable, non-radioactive lead is reached. One important member of the Uranium 238 decay series, the commonest form of uranium, is Radium 226. This is the most important component of many low-level radioactive wastes, including those in the Port Hope

area and in uranium mine and mill tailings. Another important member of the uranium decay series is the radioactive gas radon, which is present in varying concentrations worldwide and which, as a consequence, is constantly inhaled in varying degrees by everyone.

Radionuclides of the uranium decay series are examples of the earth's original store of radioactive atoms which are steadily decaying towards stability (i.e., becoming less radioactive). At the same time, new radionuclides are being formed (as in the case of Carbon 14 and Tritium), as described previously. In addition, for more than 50 years it has been possible to produce radionuclides deliberately. A wide variety of radioactive material is produced in nuclear reactors and cyclotrons for scientific research, industrial use and medical diagnosis and therapy.

The energy emitted during radioactive decay may be in the form of alpha particles, beta particles or gamma rays. These differ in their ability to penetrate tissue and other materials and in their potential toxicity (as well as in the means required to detect it), but each may be regarded as a form of radiation and, more particularly, as a form of ionizing radiation, which is discussed in the following section.

2.2 Radiation

The word radiation is commonly used in several distinct although related senses.

First, it is a term for the process by which energy is transferred and is able to exert an effect at a distance without the need for any physical connection between source and receiver. In this broad sense, radiation includes energy transfer both by electromagnetic waves (as in the case of gamma rays, ultra-violet rays or radio waves) and by energetic particles (such as alpha or beta particles emitted from nuclei in the process of radioactive decay). The more precise terms "electromagnetic radiation" and "particulate radiation" differentiate between these two phenomena.

Second, radiation is the general term applied to the whole group of different forms of energy which transfer their energy by the process of radiation. For example, "radiation" from the sun includes infrared and ultra-violet rays, visible light, X-rays, gamma rays and radio waves.

Third, the word radiation is also used as a short form for "ionizing radiation." This is often the case when harmful effects of radiation are being referred to. Ionizing radiation is radiation of various forms which has sufficient energy to cause the formation of ions in the matter with which the radiation reacts. Ionizing radiation includes X-rays, gamma rays, cosmic rays, neutrons and charged particles. Thus, energy emitted in radioactive decay may be regarded as ionizing radiation, be it in the form of alpha and beta particles or gamma rays.

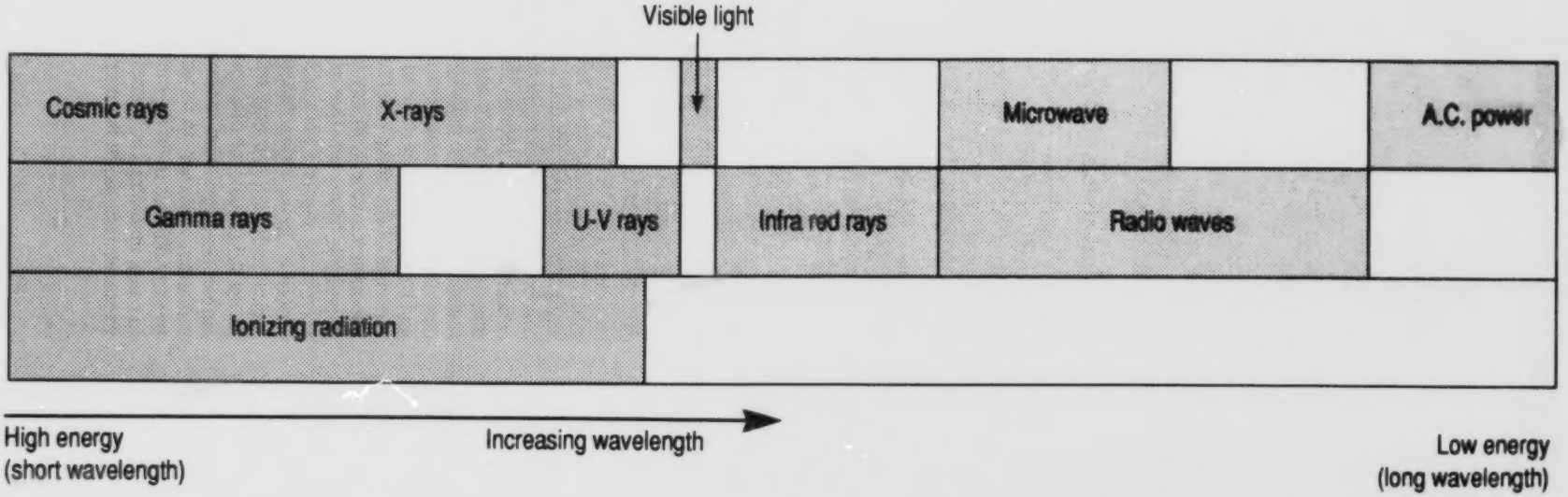
Electromagnetic radiation can be classified by the order of its energy or wavelength, just as the components of visible light may be classified in a spectrum of colours. X-rays and gamma rays occupy the highest energy, shortest wavelength end of the electromagnetic spectrum, while radio waves are at the opposite end, and visible light occupies an intermediate position. (See Figure 2.) Position in the spectrum gives a clear indication of how the different forms of radiation interact with matter on which they impinge, including human tissue. For example, X-rays and gamma rays can penetrate tissue with relative ease. On the other hand, ultra-violet radiation can penetrate only superficial layers of the skin.

The transmission of energy by radiation can be interrupted by interposing absorbing or reflecting material between the radiation source and the receiver. As examples, X-rays can be stopped by a thin barrier of lead and the burning effects of ultra-violet radiation on the skin can be stopped by a layer of clothing. Radiation that passes directly through matter, including human tissue, has no effect on it. However, radiation that is arrested in matter gives up its energy to that matter and affects it. Thus, microwaves heat and cook food in which they deposit energy, ultra-violet radiation causes the skin to tan, burn and/or undergo cancerous changes, and X-rays cause physical and chemical changes, with a variety of consequences, in the matter in which they are arrested.

Radiation, specifically ionizing radiation, is given off by numerous natural processes such as the nuclear fusion of the sun and the decay of naturally occurring minerals on earth and within our own bodies. It can also be artificially generated as in the production of X-rays for industrial or medical purposes and in the use of radioactive materials for electrical power generation, or for medical and scientific research purposes. As a result, all living and inanimate things are constantly subjected to radiation, the composition (and hence the effects) of which varies from place to place. It is largely natural and never totally absent or avoidable.

Figure 2

The electromagnetic energy spectrum



Notes

1 The scale is roughly logarithmic.

2 At the high energy end, wavelengths are much less than one trillionth of a millimetre long, i.e., .000,000,000,001 mm.
At the low energy end, the wavelengths are greater than 10 million metres.

3 The wavelength of visible light ranges from about 80 thousandths of a mm (red end), to about 40 thousandths of a mm (violet end).

4 U-V stands for ultraviolet.

5 Ionizing radiation embraces cosmic rays, gamma rays, X-rays and ultraviolet rays -- the shorter the wavelength, the more hazardous to health.

Natural background radiation

Every place on earth is bathed in ionizing radiation which comes from various sources including cosmic radiation, radiation from radioactive materials that surround everyone, the building materials in our homes, schools and places of work, radiation from the ubiquitous radon, and internal radiation from radioactive materials that are constituents of all living matter. Radiation from these sources is known as natural background radiation. Its level can vary as much as tenfold in various locations around the globe. In spite of such variation, it is not possible to demonstrate any difference in the prevalence of biological effects of ionizing radiation between populations chronically exposed to these different background radiation levels. This is one reason why it is believed that natural background radiation cannot account for more than a few percent of the world's genetic abnormalities, birth defects and cancers. Similarly, it appears unlikely that any small exposure to ionizing radiation, above natural background, can be a major cause of these conditions if the magnitude of exposure is of the same order as variations in natural background which occur from place to place. Many other factors and many other toxins have been shown to be responsible for precisely the same kinds of genetic abnormalities as those ascribed to ionizing radiation. Examples include the effects of rubella (German measles) contracted in early pregnancy, and the effects of benzopyrenes and other carcinogens present in cigarette smoke.

Exposure to ionizing radiation above background levels

Exposure to levels of ionizing radiation above natural background may be incurred voluntarily or involuntarily, deliberately or accidentally. As well, exposure may be a consequence of the industrial, medical or military use of radioactive materials, or exposure to another source of ionizing radiation. Furthermore, exposure may be direct or indirect. For example, radioactive materials are extensively used in medical diagnosis and treatment, in scientific research, and for a variety of industrial purposes. The production, distribution, use and disposal of these materials lead to potential radiation exposure of various workers and the general public in addition to the deliberate and direct exposure of medical patients and others who benefit from their exposure.

Nuclear weapons testing may affect a local environment, but can also lead to worldwide fallout of radioactive material and the involuntary exposure of a very large population. If the public perception of risk from low-level radioactive waste comes largely from the perceived probability of exposure to ionizing radiation and the perception of its consequences, then public concern should properly be for both those in the immediate vicinity of the waste and responsible for handling it, as well as those who may be affected distantly and perhaps unknowingly – as, for example, after any dispersion of wastes into the environment with the resulting potential for their concentration in food chains.

Biological effects of ionizing radiation

At very high levels, the effect of ionizing radiation upon acutely exposed living organisms can be lethal. This effect is used deliberately in the radiation treatment of cancer and the sterilization (by radiation) of medical and surgical equipment.

The levels of exposure which might conceivably be received from low-level radioactive waste are generally thousands of times less than doses used in cancer therapy, even for people who could be most directly exposed. The radiation effects that might be relevant in the case of low-level radioactive waste include increases in the prevalence of genetic defects, congenital malformations (birth defects), and neoplasms (cancers) in an exposed population. However, of all the abnormalities that might be cited as being induced by ionizing radiation, none is specific to radiation damage alone. In any population exposed to low-level radiation doses such as those from low-level radioactive wastes, there will be many more genetic abnormalities, birth defects and cancers that arise spontaneously or are due to other causes, than could conceivably be due to such radiation exposure. In fact, in any study of low-level radiation effects, the major problem is always to detect the signal (incremental cases of birth defects and cancers actually induced by radiation) in the presence of the noise (the much larger number of spontaneous cases). In any individual case, it is impossible to say whether or not a given effect is specifically due to a person's exposure to ionizing radiation. In large populations studied by epidemiological techniques, it may be possible to attribute an increased prevalence of a specific effect to the exposure of the population to elevated levels of ionizing radiation. However, in technical terms, this is extremely difficult to do for human populations, even in cases involving the highest level of radiation exposure that might be received.

It is a conventional radiobiological assumption that any level of ionizing radiation above background, even levels which are immeasurably small, will increase the probability that an adverse effect will occur in an exposed individual. This may lead to the view that no level of exposure to radiation is safe and, further, that any reduction in exposure which can be achieved is desirable, regardless of the difficulty or inconvenience involved in achieving it. It also may suggest that ionizing radiation is uniquely dangerous as compared, for example, with chemical toxins for which so called "safe" levels have been formally declared. This is far from the case. With certain chemical toxins, particularly those which are synthetic, it is reasonable to think that zero concentrations in the body or in the environment are desirable, even if not easily achievable. No level of these substances can be thought of as natural or normal, yet "safe" levels of such substances, (i.e., concentrations below which toxicity cannot be demonstrated) are frequently declared. Ionizing radiation has been an integral component of the environment in which life was developed on earth, yet it is often assumed that no increase over the particular background level at any given place is without risk. This issue of safe levels is again discussed in Chapter 5.

The risk of untoward effects from the levels of ionizing radiation to which the general public is exposed, except in the most extraordinary circumstances, is extremely small both in absolute terms, and in relation to other types of risks which society deems acceptable. However, any given cause of exposure to ionizing radiation at levels above natural background may be judged morally less defensible or socially less desirable than another. For example, some people will claim that involuntary exposure to radiation from weapons testing fallout is a necessary price for defending their desired way of life. Others will regard it as an outrage.

Exposure to ionizing radiation does not affect all the population equally. Variations in natural backgrounds from place to place result in different exposures in different communities and even between neighbours when the contribution of radon is taken into account (see Appendix D).

The use of radioactive materials results in both benefits and risks. In this context, it is of interest to note that the average exposure of North Americans to diagnostic X-rays and radioactive materials is now approximately equal to background radiation. Decisions as to the use of radioactive substances should include consideration of both benefits and risks, but it must be appreciated that risks may not be borne by the same individual or community which enjoys the benefits.

It is self-evident, but needs emphasis, that the effects of ionizing radiation on human health and the environment know no moral or philosophical distinction and do not vary according to whether the source of radiation is judged good or bad, or whether exposure is voluntary or involuntary.

Chapter three
Low-level radioactive waste

Radioactive waste may be defined as:

> Material which is a product of deliberate processing and which contains radionuclides (radioactive elements) in a greater concentration than that considered safe for uncontrolled release into the environment and for which no further use is foreseen.

Accordingly, naturally occurring uranium ore is not radioactive waste, but uranium mine and mill tailings are. Spent fuel from nuclear power stations is regarded as waste in Canada because no further use is envisaged for it, whereas in countries where reprocessing is undertaken, it is not considered waste. It is appreciated that acceptance of this definition begs the question as to what constitutes "safe for uncontrolled release." In the Canadian context, this judgement is made by the AECB for each individual radionuclide through its system of setting "scheduled quantities." The Board publishes these schedules from time to time as regulations under the Atomic Energy Control Act.

3.1 Waste production

Early radioactive wastes in Canada resulted from the production of radium for medical use, primarily for the treatment of cancer. As interest in nuclear energy increased in the early 1940s, the emphasis shifted from the production of radium to the processing of uranium. With this switch, the nature of the waste changed.

Some radium is still used in the treatment of cancer, but other radioactive materials find more extensive use in clinical medicine, not only in the treatment of cancer and benign diseases but also, through the techniques of nuclear medicine, in the diagnosis and monitoring of a whole spectrum of diseases. For example, medical, scientific and industrial research in universities, government and private institutions relies heavily on radioactive tracer methods. Radionuclides are also used for the sterilization of medical supplies, for industrial radiography (such as testing the integrity of pipeline welds and aircraft parts) and in smoke detectors and other monitoring devices. The use of radioactive materials has grown to the point where the AECB now licenses more than 5,000 users of radioactive materials throughout Canada. In addition, while some of the radionuclides for medical, research and industrial use are imported, many are produced in Canada. Moreover, Canada has a substantial and profitable trade in these materials. However, the production and use of radioactive materials for these purposes inevitably produce low-level radioactive waste, as does the generation of electricity by nuclear reactors.

3.2 Present classification of wastes

The challenges of radioactive waste management are not unique to Canada; they are faced by all countries with such wastes.

The types of wastes involved vary not only within each country, but also from country to country. Accordingly, all countries have found it necessary to classify and distinguish between the various kinds of radioactive wastes as a prelude to devising strategies for their management. Unfortunately, no simple or universally accepted system of classifying radioactive wastes exists. In fact, most countries, with the important exception of the United States, have tended to devise classifications which are administratively convenient (i.e., suited to their respective specific institutional arrangements for the regulation and management of such wastes), rather than systems based primarily on scientific or technical criteria which would be of more help in waste management planning.

Canada has adopted this administrative practice. The traditional approach has been to classify radioactive waste into two categories, "high-level" and "low-level." The "high-level radioactive waste" category comprises only the spent-fuel component of the wastes from nuclear power stations. All other radioactive waste is, therefore, "low-level radioactive waste." However, very early in its deliberations, the Task Force learned that the term "low-level radioactive waste" has neither a unanimously accepted definition nor a scientifically based classification. As a means of resolving this issue, Canadian practice has been to base the definition of low-level

radioactive wastes on the division of administrative responsibilities. For example, the Federal Government Policy on the Management of Low-Level Radioactive Wastes (Appendix B) uses four administrative categories: historic radioactive wastes, low-level radioactive wastes, mine and mill tailings, and incidental wastes.

- ***Historic radioactive wastes*** are those wastes which were managed in the past in a manner no longer considered acceptable but for which the original producer cannot reasonably be held responsible. They are now managed by the Low-Level Radioactive Waste Management Office of AECL on behalf of the federal government.
- ***Low-level radioactive wastes*** include all forms of radioactive wastes except those derived from uranium or thorium mining and milling operations and from irradiated nuclear fuel. They are managed by each organization across the country that produces or uses radioactive material including universities, hospitals, manufacturing industries and the nuclear energy industry.
- ***Mine and mill tailings*** are those wastes generated during the mining and milling of uranium and thorium ores. In general, they are managed by the mining companies; in some cases, however, where companies have ceased to operate, the tailings are unmanaged.
- ***Incidental wastes*** are those wastes arising from industrial processes not related specifically to the generation of radioactive material but where such material is naturally present in the raw material. This is the case, for example, in the production of carborundum and phosphogypsum. In general, these wastes are managed by the companies involved in production activities.

This categorization may have been valid and may have had administrative convenience in the past. However, for a number of reasons, the Task Force has determined that the continued usefulness of this approach to defining and classifying low-level radioactive waste is questionable. First, this administrative categorization has led to a considerable degree of confusion on the part of the general public since the definitions do not help the public understand the relative hazards of the different materials or the different methods required to handle the wastes, even within a single category. For example, the Task Force frequently heard, "Aren't all these wastes low-level wastes?" The answer, of course, is yes. Because of this, the non-specialist may well come to regard all low-level radioactive wastes as being equally hazardous. Yet the fact is that there are large differences between certain reactor wastes, on the one hand, and historic radioactive wastes on the other. Their concentrations of radioactivity and their half-lives may differ by factors of several thousand, although both are currently termed "low-level wastes." Equally, the hazards they pose are quite different. It is for this reason that, although it has not been the policy of the Board to subclassify low-level radioactive waste, de facto subclassification has occurred and is observed by both Ontario Hydro and AECL in their approaches to waste management.

Second, the administrative-based classification tends to obscure the extent and complexity of the problems of waste management. For example, the categorization implies that "historic radioactive wastes" and "uranium mine and mill tailings" are significantly different in their physical nature and radiation hazard, even though this is not the case. Similarly, the classification seems to suggest that wastes in these two categories, together with "incidental wastes," are somehow different from "low-level wastes."

Third, the current categorization of wastes does not provide adequate guidance relative to the management requirements applicable to each category of wastes. This is because it distinguishes categories in terms of source and administrative responsibility, rather than in terms of physical characteristics and relative radiation hazard. However, it is these physical and radiation properties as well as the volume of wastes that are fundamental to the determination of appropriate waste management practices.

3.3 An alternative approach to the classification of wastes

An unambiguous waste classification system is an essential prerequisite to effective resolution of the problems and issues of low-level radioactive waste management. Gaining public acceptance of any proposed management solutions will demand clear definition of the wastes and their management requirements. The current system of waste classification fails to meet these criteria.

The Task Force's assessment of this problem led it to develop its own definition and classification system, based primarily on the specific activity and half-life of the materials involved. First, it defined low-level radioactive waste as being:

> **all those radioactive wastes, other than spent fuel, arising from the mining, milling, refining or use of materials containing radionuclides.**

Second, it divided low-level wastes into four categories or classes as illustrated in Table 1. The classes are based on the concentration of radioactivity (measured in gigabecquerels per cubic metre [GBq/m^3]) of the waste material (a becquerel is defined as one nuclear disintegration per second). Each class is described in some detail in the text which follows.

Table 1

An alternative approach to the classification of low-level radioactive wastes

Class	Average specific activity	Half-life
0	≤ 1.0 GBq/m^3	> 500 Years
I	> 1.0 GBq/m^2 to ≤ GBq/m^3	< 50 Years
II	> 10 GBq/m^3 to ≤4000 GBq/m^3	< 50 Years
III	> 4000 GBq/m^3	< 50 Years

Class 0

The designation "0" for the first class was not chosen by the Task Force to minimize any perception of risk, but so that Classes I, II and III will be similar to Ontario Hydro's low-level radioactive waste Classes 1, 2, and 3.

This category includes wastes with relatively low concentrations of radioactivity (an average of less than or equal to 1.0 GBq/m^3). The half-life of the longest lived constituent radionuclide is greater than 500 years. In this category the Task Force includes the uranium mine and mill wastes, the incidental industrial wastes, the historic wastes in Port Hope and Scarborough, some of the wastes stored at the Chalk River Nuclear Laboratory, the wastes at Welcome, Port Granby and the Bruce Nuclear Power Development, as well as some ongoing wastes from other producers.

Class I

This class of wastes includes ongoing wastes with typical average concentrations of radioactivity, after compaction or incineration, of greater than 1.0 GBq/m^3 up to 10 GBq/m^3. It includes wastes produced at nuclear power stations such as Pickering and Bruce, waste from the decommissioning of Douglas Point, and a small amount of waste from the original, recently decommissioned nuclear power development at Rolphton. Also included is waste resulting from medical, research, and industrial activities.

Much of such wastes consists of comparatively lightly contaminated materials such as paper and plastic sheeting, glass and rubber, protective clothing, cleaning materials and hardware. Such wastes may undergo compaction or incineration resulting in volume reduction by ratios of about 6:1 for compaction and 75:1 for incineration.

Class I wastes are currently stored at the Chalk River Nuclear Laboratory in well-drained sand trenches well above the water table and at the Bruce Nuclear Power Development in above-ground storage facilities. Those medical, research and industrial wastes which cannot be managed on-site by normal disposal methods are transported to Chalk River for long-term storage.

The major constituents in Class I wastes are short-lived radionuclides (half-lives of less than 50 years) such as Cobalt 60, Cesium 137, and Strontium 90.

Class II

This class includes wastes (a small proportion of which have been compacted or incinerated) with typical average concentrations of radioactivity ranging from greater than 10 GBq/m^3 to less than or equal to 4000 GBq/m^3. The major constituent radionuclides are the same as for Class I.

The ongoing wastes of this class consist of nuclear reactor maintenance wastes, particularly filters from purification systems and some ion exchange resins, some AECL wastes (especially from the Chalk River operations) and a small proportion of the waste from the medical, research, and industrial uses of radionuclides.

Wastes from this category are currently stored in engineered asphalt trenches and concrete bunkers at the Chalk River Nuclear Laboratory and in concrete trenches at the Bruce Nuclear Power Development.

Class III

This class consists of wastes with typical concentrations of radioactivity greater than 4000 GBq/m^3. The major constituents are the same as for Classes I and II and have half-lives of less than 50 years.

Special requirements for CANDU wastes

The low-level wastes produced as a result of operating CANDU reactors for the production of electrical power are difficult to accommodate precisely in the above classification. Wastes from nuclear power stations, which would be classified as Class I or Class II by the activity levels and half-lives of their major components, may contain traces of Carbon 14 and transuranic nuclides. Although this would ostensibly exclude such wastes from Classes I and II, for which the stated half-life is less than 50 years, the Task Force has been advised that, in practical terms, the concentrations of long-lived constituents are too small to warrant a distinction. It would thus seem reasonable that levels of Carbon 14 and transuranic nuclides approximately equal to those in current CANDU nuclear power station wastes should not in themselves exclude such wastes from classification as Class I or Class II where otherwise appropriate. Similar action has been taken in the United States with regard to trace contaminants and the classification of low-level wastes in force in that country.

A more difficult problem arises on consideration of the CANDU reactor wastes, comprising filters and ion exchange resins, currently termed Class III wastes by Ontario Hydro and stored in above-ground quadricells and in-ground tile holes at the Bruce Nuclear Power Development. In these wastes, Carbon 14, with its half-life of 5730 years, is no longer a minor contaminant, but rather the major constituent. This excludes such material from Class III wastes by the proposed definition. Given that the containment of Carbon 14 may pose special difficulties in the longer term, and that the inventory of stored Carbon 14 will inevitably rise as a result of the existing commitment to nuclear power generation in Ontario, it is possible that long-term storage of wastes containing Carbon 14 from CANDU reactors, which might otherwise be classified as Class III, should be undertaken in the same facilities that will be required for the spent fuel. In view of the foregoing, the Task Force suggests that urgent consideration be given to the waste management requirements of Carbon 14.

The Task Force's classification scheme is not intended to be applied to wastes of such a short half-life and low activity that they are better managed by secure temporary storage for a period of a few weeks or months at their site of production. For example, wastes containing Iodine 131 (with a half-life of 8 days) are frequently stored for 10 half-lives or more in the hospitals in which they have been generated. Thus, in 12 weeks, a given activity level of Iodine 131 diminishes to less than a thousandth of the original and the disposal problem it poses diminishes correspondingly. After such temporary storage, the activity of the waste may have declined so much that the material can be regarded safely as non-radioactive, or the residual activity may allow the waste to be consigned to the appropriate category in the proposed classification.

The advantage of this classification scheme is that it allows for a direct linkage between each type of waste and its appropriate management techniques (which are discussed in the next chapter). For example, wastes in Class 0 are long-lived, high-volume, low specific activity materials some of which may be managed in situ. By contrast, wastes in Class II for the most part are short-lived, low in volume, relatively high in specific activity and require special containment and controls.

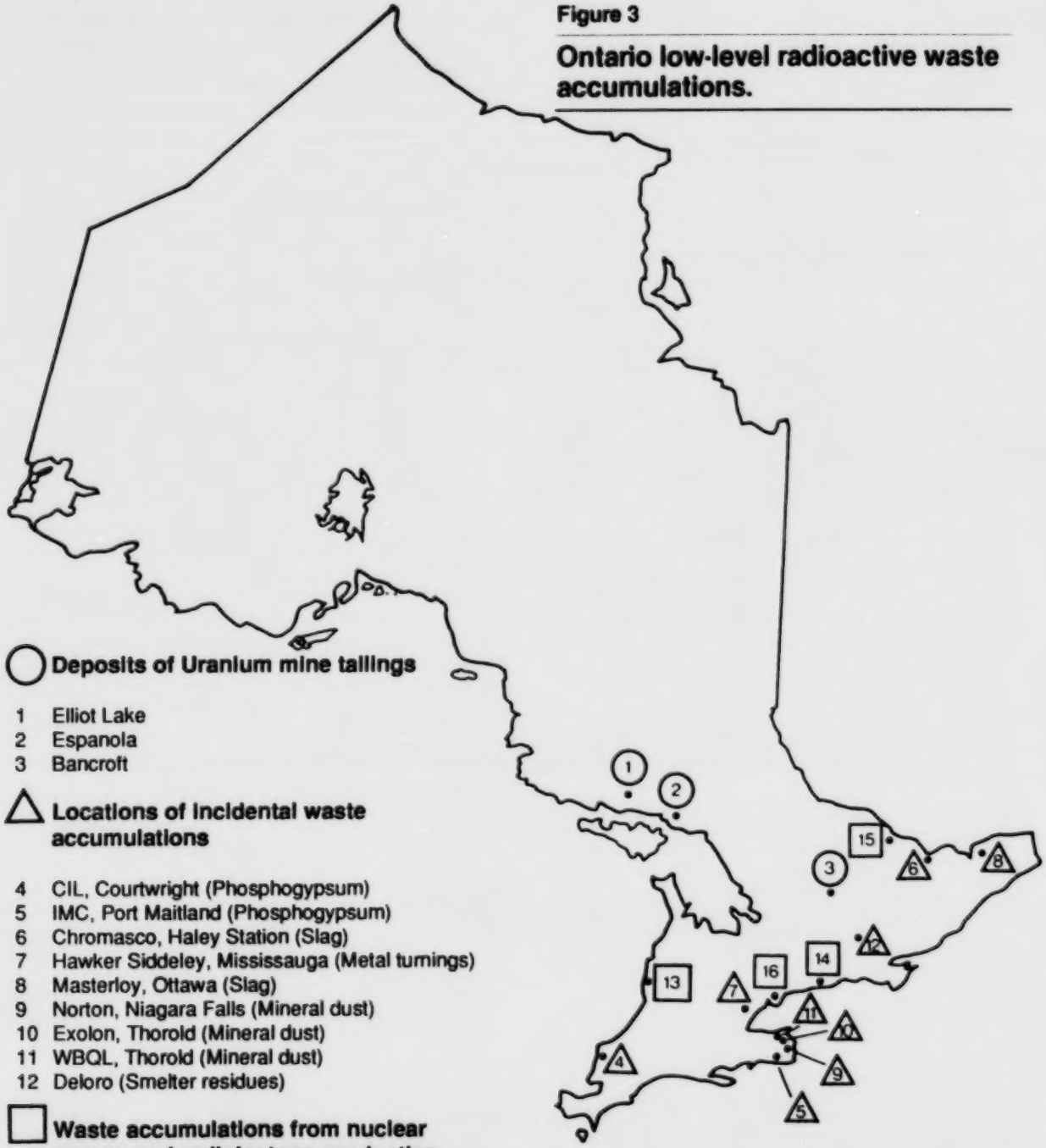
As is clearly demonstrated by the presentation of this new classification system for low-level radioactive wastes, Task Force members were convinced of the benefit of having a comprehensive classification scheme based on the fundamental properties of wastes as outlined. Given the sensitivity of the issues of low-level radioactive waste management and the vital role played by a classification system in circumscribing management requirements, the Task Force urges the federal government to move quickly to refine and adopt this classification of low-level radioactive wastes for use in waste management activities.

3.4 Inventory of waste quantities

Radioactive wastes result from numerous activities carried on throughout Canada. Many of these activities generate wastes in only very small quantities. Frequently the wastes have very short half-lives and may not create much of a waste management problem (e.g., on-site storage for 10 half-lives results in the material becoming essentially non-radioactive). However, Ontario, with its uranium mines, its nuclear power programs, its industrial base and its long history in the use of radionuclides in medicine and industry has accumulated about 136 million cubic metres of low-level radioactive wastes. It has by far the largest share of such wastes in Canada, although several other provinces have significant volumes of low-level wastes. For example, Saskatchewan, where the world's richest known uranium ore bodies are located, has about 14 million cubic metres of waste from several mine/mill operations. British Columbia has 3,000 cubic metres of wastes from the import of niobium concentrate for steel making. Quebec and New Brunswick each have small quantities of wastes resulting from their nuclear power programs.

Figure 3

Ontario low-level radioactive waste accumulations.



○ Deposits of Uranium mine tailings

1 Elliot Lake
2 Espanola
3 Bancroft

△ Locations of incidental waste accumulations

4 CIL, Courtwright (Phosphogypsum)
5 IMC, Port Maitland (Phosphogypsum)
6 Chromasco, Haley Station (Slag)
7 Hawker Siddeley, Mississauga (Metal turnings)
8 Masterloy, Ottawa (Slag)
9 Norton, Niagara Falls (Mineral dust)
10 Exolon, Thorold (Mineral dust)
11 WBQL, Thorold (Mineral dust)
12 Deloro (Smelter residues)

□ Waste accumulations from nuclear energy and radioisotope production and use

13 Bruce Nuclear Power Development
14 Port Hope
15 Chalk River Nuclear Laboratories
16 Scarborough

Because of the significant quantity of wastes located within the province, the Task Force was asked to concentrate its attention on Ontario's low-level radioactive waste management situation and needs. As part of its review, the Task Force examined the characteristics of each known waste site in the province. It commissioned a report titled, "Inventory of Waste Quantities," herein referred to as the Inventory, which documents the location (Figure 3), volume and form of all currently known low-level radioactive wastes in the province. The Inventory is available as background material to this Task Force report.

Table 2

Summary of waste quantities

Waste category	Locations	Estimated volume m^3	Principal contaminants	Characteristics
Uranium mine tailings	Elliot Lake, Espanola and Bancroft	121,000,000	Radium and thorium. Various non-radioactive heavy metals.	Sand-size and smaller particulate material, often saturated with moisture. Old tailings commonly re-vegetated. Production of acidic leachate a major problem.
Nuclear energy and radioisotope wastes	Port Hope area	797,000	Arsenic, radium and uranium.	Various chemical processing residues, contaminated soils and demolition debris.
	CRNL	113,000	Mixed fission products, and activation products. Major radionuclides are tritium, Cobalt 60, Strontium 90, Cesium 137, Carbon 14. Contaminated soils from Port Hope.	Reactor maintenance wastes, laboratory and hospital trash and sealed radioisotope sources.
	BNPD	14,600	Similar to CRNL wastes.	Reactor maintenance wastes, laboratory trash.
	Scarborough	3,300	Radium and arsenic.	Contaminated soils.
Incidental wastes	Courtright and Port Maitland	14,300,000	Radium, uranium and thorium. Fluoride is a non-radioactive component.	Large mounds or ponds of phosphogypsum (calcium sulphate).
	Haley Station, Mississauga, Ottawa, Niagara Falls and Thorold	28,400	Thorium, radium and uranium	Metal turnings, slags and mineral dust.
	Deloro	100,000 (plus about 300,000 m^3 of contaminated soil)	Arsenic, radium and uranium plus other heavy metals.	Metal refinery slag and contaminated soils.

Source: Low-level Radioactive Waste Management Office, August 1987.

The Inventory lists the sources of low-level radioactive wastes. It provides information on those wastes that result from uranium mining, the refining of radium and uranium, the production and use of nuclear fuel in commercial power and research reactors, and from medical and industrial uses. It also lists the low-level radioactive wastes that came from and continue to come from the use, by certain industries, of raw materials containing above-average concentrations of naturally occurring radionuclides. With regard to the accumulations of low-level radioactive waste that exist in Ontario, Table 2 summarizes their respective locations, approximate volumes, characteristics and principal contaminants. Figure 4 indicates the current annual production of low-level radioactive wastes in Ontario.

An assessment of all low-level radioactive wastes known to exist in Ontario invites juxtaposition of the different categories of wastes and comparisons of their chemical and physical nature. Such an evaluation makes clear the essential similarities that exist between the Port Hope wastes, the Scarborough wastes, phosphogypsum incidental wastes, the Deloro deposits, and uranium mine and mill tailings. No matter how these categories of wastes may have been separated in the past, it is readily apparent now that they should be considered together (or at least compared) in terms of any impact on human health or the environment.

In addition, the waste Inventory reveals that, in many cases, wastes include more than just radioactive material. Many of the waste deposits are also contaminated with other toxic materials. For example, the Welcome waste management facility in the Port Hope area and the mine tailings at Elliot Lake contain material contaminated with arsenic. Frequently these substances are equally important, if not the dominant factors in determining the hazards associated with the wastes. The implication is that in the development of waste management practices, measures to deal with toxic chemicals will have to be emphasized.

The Inventory also shows that in some cases there are important differences between the constituents of the wastes that were produced in the past and those now being produced. Initially, refinery wastes resulted from processes used to recover radium. Later on, such wastes resulted from different processes used to recover uranium. In addition, the refining of uranium at Blind River rather that at Port Hope, and the emplacement of refinery wastes back in the mines from which they originated near Elliot Lake, have altered both the location and magnitude of the management problem for ongoing low-level radioactive refinery wastes. On the other hand, the form and composition of uranium mine and mill tailings related to uranium production have not changed recently and are unlikely to do so, unless there is a switch in uranium production away from Ontario.

Figure 4

Current annual production of low-level radioactive waste in Ontario (from Inventory Waste Quantities, 1987)

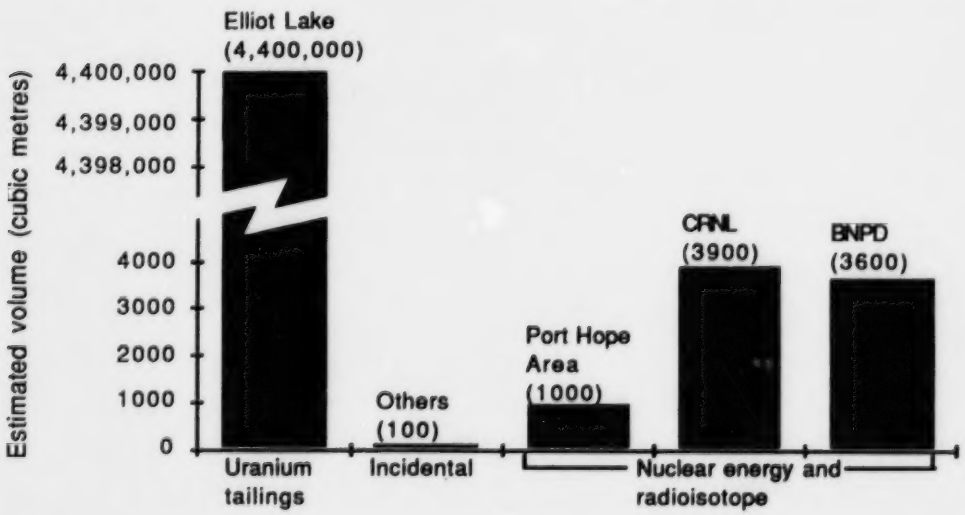


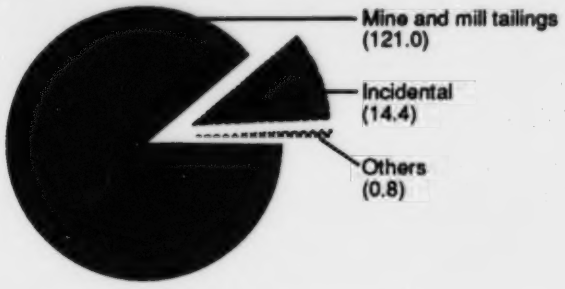
Table 3

Classification of Ontario's low-level radioactive waste (1985)

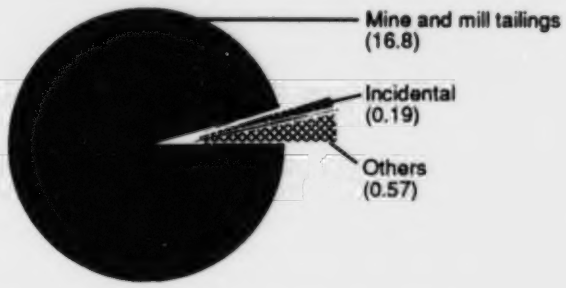
Class or category	Source and location	Description	Volume m^3	Major contaminants	Average specific activity (GBq m^3)	Total inventory of radioactivity (G Bq)
0	Uranium mines & mills, Elliot Lake, Bancroft, etc.	Mine & mill tailings contain all constituents of original ore — most of uranium removed.	121,000,000	Uranium, thorium, radium & radium daughters	0.139	15,972,000
	Uranium refinery, Port Hope	Harbour sediments, contaminated soils, cinders, ash, building materials, etc.	797,000	Uranium, arsenic thorium, radium & radium daughters	0.715	330,755
	Incidental wastes CIL-Courtright; IMC-Pt. Maitland etc.	Industrial wastes, chiefly phosphates from fertilizer production, slag, dust & soil	14,430,000	low concentrations of uranium, thorium, radium, radium daughters & arsenic	0.013	216,450
	Town of Port Hope refinery wastes transported to CRNL	Contaminated soils etc.	72,000	Uranium, arsenic, thorium, radium, radium daughters, & arsenic	0.028	504
I	CRNL operations; medical & industrial instruments, trash, research equipment, etc.	Contaminated materials — cloth, paper, glass, rubber, research equipment, etc.	area B 13,600 area C 19,300	Miscellaneous fission and activation products — Cobalt 60, Strontium 90, Cesium 137	0.40 area B 0.21 area C	5440 4053
	BNPD operations — Pickering, Bruce, (in future) Darlington	Contaminated materials — cloth, rubber, glass, — medical equipment, etc.	7,870	Miscellaneous fission and activation products — Cobalt 60, Strontium 90, Cesium 137, etc.	2.60	20,462
II	CRNL operations; medical & research laboratory waste	Contaminated reactor components, air filters resins, etc.	area B 6,520	Hydrogen 3, Carbon 14, Cobalt 60, Cesium 137, Strontium 90	37.0	241,240
	BNPD Pickering, Bruce, (in future) Darlington	Reactor maintenance wastes filters, resins, etc.	5,220	Hydrogen 3, Carbon 14, Cobalt 60, Cesium 137, Strontium 90	37	193,140
III	CRNL operations	Reactor components, decommissioning wastes, etc.	580 +	Hydrogen 3, Carbon 14, Cobalt 60, Cesium 137, Strontium 90	>3700	2,320,000 to 20,000,000
	BNPD operations	Highly contaminated resins and irradiated core components	400	Hydrogen 3, Carbon 14, Cobalt 60, Cesium 137, Strontium 90	1,900 to 370,000 (short half-lives)	760,000 to 3,000,000

Figure 5

Class 0 wastes in Ontario



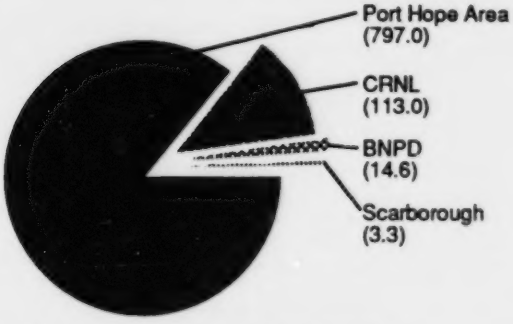
Volumes in millions of cubic metres



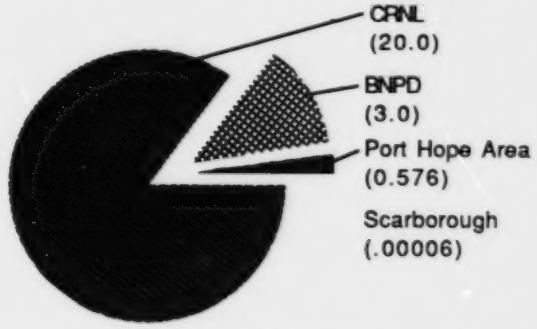
Inventory of radioactivity in millions of GBq

Figure 6

LLRW resulting from nuclear energy and radioisotopes



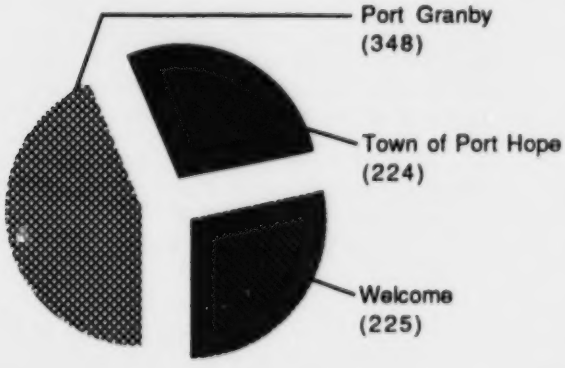
Volumes in thousands of cubic metres



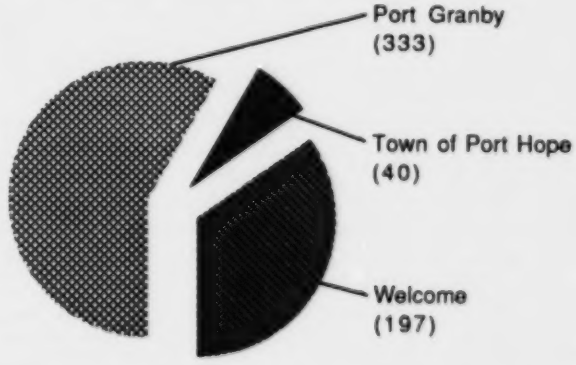
Inventory of radioactivity in millions of GBq

Figure 7

Port Hope area low-level radioactive wastes



Volumes in thousands of cubic metres



Inventory of radioactivity in thousands of GBq

Table 3 shows the relative proportions of the different classes of low-level radioactive wastes as defined in the suggested classification scheme. It should be noted that Class 0 comprises the greatest volume of waste material in Ontario. To better appreiate the low-level waste situation in Ontario, and most notably for purposes of this report, in the Port Hope area, Figures 5, 6 and 7 illustrate essential information detailed in the Inventory. Figure 5 outlines the distribution of Class 0 wastes. It is noteworthy that mine and mill tailings dominate in both volume and specific activity. Figure 6 shows the "other" category of Figure 5 again, this time by volume and total activity. In this instance it is clear that while the Port Hope area wastes dominate by volume, they are far less significant by specific activity. Figure 7 illustrates the significance of the various waste sites in the Port Hope area. Of particular relevance is the difference between volume and specific activity. These figures illustrate clearly the magnitude and scale of the problems involved with managing low-level radioactive wastes and their various constituents.

3.5 Conclusions and recommendations

The current classification of radioactive wastes in Canada represents a liability in any effort to make facility siting more co-operative. The simple classification of radioactive waste into high and low levels according to administrative responsibilities is neither informative nor helpful to the public. Furthermore, this system does not provide a clear indication of the characteristics of the different kinds of low-level radioactive wastes and, more importantly, their specific management requirements. In fact, it may mislead and thereby misinform the general public.

The Task Force has attempted to develop a four-part classification system which it believes will be more readily understood by the general public.

Accordingly, we, the members of the Task Force recommend the establishment of an expanded and more meaningful classification system for low-level wastes. Our investigation of this subject revealed that it is not only beneficial, but also feasible to classify low-level radioactive wastes according to their fundamental properties and associated management requirements.

Further, we strongly recommend that the federal government undertake a more detailed technical study of such a system so that it can be incorporated into future low-level radioactive waste management activities.

Finally, we also recommend that urgent consideration be given to the waste management requirements of Carbon 14 in view of its concentrations in certain CANDU wastes.

The waste Inventory revealed that, in many cases, non-radioactive toxic substances such as arsenic are present in existing accumulations.

Accordingly, we recommend that regulatory authorities ensure that management requirements established for specific low-level radioactive waste accumulations take into account their non-radioactive contaminants.

Chapter four
Low-level radioactive waste management

4.1 Responsible management

All the industrialized world is facing waste management problems presented by the many categories of industrial and domestic wastes, of which low-level radioactive waste is only one. In all cases, proper management of waste requires that its particular characteristics and potential hazards be well understood. The unique property of radioactive wastes is that they emit, to varying extents, ionizing radiation.

The biological effects of ionizing radiation depend on the interaction of the energy of the radiation with living tissue. However, it is necessary for a "hit" to be scored and, in the case of radioactive material, such a "hit" requires relatively intimate exposure of the tissue. The reason for this is the relatively limited penetrating power of alpha and beta particles, as previously explained in Chapter two and detailed in Appendix D. Thus, for alpha-emitting material to have an effect on higher animals, it must be ingested (swallowed, inhaled or deliberately injected). Beta-emitting material must be ingested or come in direct contact with the surface of the body. Only gamma-emitting material can cause harm from a distance, but even then, the dose of radiation received falls off significantly as the distance increases since the inverse-square law applies (e.g., if the distance from the source doubles, the dose received falls to one quarter; if it quadruples, the dose falls to one sixteenth; and so on).

Consequently, responsible management calls for special measures to confine the wastes and thus limit their potential toxic effects on the biosphere. As well, it necessitates the choice of specific management concepts and appropriate technology to address specific waste characteristics. The seven most important waste characteristics are:

- the radioactive half-lives of materials in the wastes;
- their volume;
- their concentration;
- their solubility;
- their physical state (liquid, solid or gas);
- their chemical and biological state; and
- whether they contain non-radioactive contaminants and associates.

1 The radioactive half-lives of the wastes

As noted in Chapter two, each of the approximately 1800 known radionuclides has a characteristic half-life that ranges from a fraction of a second to billions of years. For example, the radioactive substance most commonly administered to patients in medical diagnosis is Technetium 99m which has a half-life of six hours. Safe management of Technetium 99m waste requires only short-term storage, because in 72 hours its activity decays to less than one four-thousandth of the original level. Likewise, a release of Technetium 99m to the environment carries a limited risk when compared with that of a radionuclide with a longer half-life. For example, Radium 226, an important constituent of some of the Port Hope wastes, has a half-life of 1600 years and, unlike Technetium 99m (which decays to a stable substance) Radium 226 decay yields progeny that are themselves radioactive.

2 The volume of the wastes

Volume is a major factor in determining how to achieve safe and responsible waste management. The significance of this factor is evident if one compares the problems inherent in managing an amount of waste radium the size and shape of a small needle with those of managing typical accumulations of uranium mine and mill tailings which have volumes amounting to millions of cubic metres. Furthermore, the waste volume to be managed can change significantly with time. For example, only relatively small volumes of wastes are produced today; by themselves, they require only small ongoing waste management facilities. However, there is a large volume of existing wastes that needs improved management and must be taken into account in any waste management plan.

3 The concentration of the wastes

It is the concentration of radioactive material, rather than its absolute amount, which, like that of other toxins, determines its potential to create negative impacts on health and the environment. For example, everyone is well aware that even a tiny drop of highly corrosive fluid splashed in the eye must be washed out – its toxicity and impact reduced by dilution. Similarly, small amounts of radioactive waste may be dangerously toxic when only slightly diluted in one litre of water, but may be harmless when diluted in tens of thousands of litres.

It may be both sensible and responsible management to treat certain concentrations of some short-lived radionuclides by first diluting them to reduce their potential toxicity and then releasing them into the environment. However, the issue is not so simply dealt with, as shown in the popular environmental chant – "The solution to pollution is not dilution."

The Task Force is well aware, as is the scientific and regulatory community, that the "dilution" approach to waste management requires careful application. The continued discharge of concentrations of toxic materials, which are not in themselves dangerous, into an environment with a finite capacity may lead to the gradual build-up of the material in that environment. This saturation is more dangerous in cases where toxic materials released in relatively low concentrations into the environment become more concentrated by passage along the food chain. For example, the build-up of the insecticide DDT in the environment and its concentration in the food chain resulted in toxic effects appearing in certain birds of prey. Clearly, those toxic substances, such as DDT, that do not break down or become inactive by evolving or changing into some biodegradable form, are unsuitable for management by discharge after dilution, particularly if a concentrating mechanism exists. On the other hand, many radionuclides with short half-lives that pose no threat of build-up can be safely managed by dilution and discharge. Notwithstanding the foregoing, caution must be exercised with materials subject to a concentrating mechanism, such as the radioiodines that can accumulate in the thyroid gland of various animal species.

It is the Atomic Energy Control Board which defines the maximum permissible concentrations of radionuclides in water and food. Similarly, the Board defines the allowable quantity of radionuclides that may be released into the environment in water, air and solid waste. In determining such levels, the Board uses the concept of "scheduled quantity" – a measure of potential toxicity that takes into account the nature of the radioactive emission, its half-life and its bio-distribution.

4 The solubility of the wastes

The solubility of the radioactive and non-radioactive components of any given waste is a major determinant of the likelihood of it escaping from confinement or migrating in such a way that it poses a health or environmental threat. In the Port Hope area wastes, Radium 226 is the primary radioactive component. It is relatively insoluble and resistant to leaching. However, some Port Hope wastes are also contaminated with arsenic, a substance that is readily soluble and may pose a more serious threat than the Radium 226 itself. While solubility is the major concern, management plans must not overlook the fact that insoluble particles may be dispersed by bulk movement, (e.g., as a result of the scouring action of water).

5 The physical state of the wastes

Low-level radioactive wastes can exist in solid, liquid or gaseous form. Any solid waste may give off a radioactive gas, as in the case of Radium 226 which gives off Radon 222 when it undergoes alpha decay. Water flowing through a solid waste may leach out soluble radioactive material (e.g., the acid leachates of some uranium mine tailings). As well, solid fine particulates of radioactive waste may take the form of a dust and be carried away on the wind, as is the case in the erosion of mine tailings. Equally, non-radioactive dust particles in the atmosphere can be contaminated with radon daughters as a result of electrostatic attraction. Furthermore, fine solid or liquid radioactive wastes can also take the form of aerosols that, once airborne, may be widely scattered.

The physical state of wastes is, of course, important to the process selected for waste management. For example, the relative ease of confining a solid, as compared to a liquid, makes solidification an important option in low-level radioactive waste management. Part of the price of solidification, however, is an increase in volume and weight of the treated liquid waste. By contrast, incineration of low-level radioactive wastes may be appropriate to reduce waste volume or destroy associated substances such as organic solvents.

6 The chemical and biological state of the wastes

The chemical state of a low-level radioactive waste may affect its toxicity by influencing such characteristics as reactivity, solubility and volatility. Similarly, the waste material's biological state can be important in its safe management. For example, when medical patients receive radioactive materials diagnostically and therapeutically, the radioactive content of excretory products may require safe handling. Wastes containing radioactive Iodine may pose a particular threat, as Iodine taken into the body becomes concentrated approximately fifty-fold in the thyroid gland.

7 The non-radioactive contaminants and associates of the wastes

Non-radioactive substances associated with or contaminating low-level radioactive wastes may be important determinants, or even the dominant determinant, of their toxicity and, hence, point to the means necessary to manage them. The arsenic content of the Port Granby waste is an example of this, as is spent liquid scintillation counting fluid waste produced by numerous medical and other research laboratories. While the radioactive content of such material may barely exceed the level of Hydrogen 3 (Tritium) that may be safely released to the environment, it is nevertheless a toxic, flammable, organic solvent.

Most of the technical problems of radioactive waste management are not new or particularly challenging when compared with some of the issues that have recently surfaced in relation to toxic materials such as dibenzofurans and dioxin. In fact, the greatest difficulty faced in radioactive waste management is not technical, it is social. It is the problem of effectively responding to the public perceptions of the dangers of radiation and the peculiar dread in which the public holds all things having to do with radiation and radioactivity. Furthermore, there are problems created by the equivocal nature of the relationship between people and technology that is a feature of modern society.

Some modern technologies are granted an uncritical trust while others, or even the same ones under other circumstances, provoke distrust. For example, the public regards the use of radiation in the detection and treatment of disease very differently than it does other uses of radiation, even though the underlying science and technology are the same. Furthermore, and inevitably, any present public perception of the risks of radiation is clouded by the Chernobyl incident. The matter of public perceptions of radioactivity and risks is elaborated upon later in this report in Chapter five.

The development of a responsible approach to the management of low-level radioactive wastes requires a comprehensive assessment of technological options. As noted, technical concerns in radioactive waste management are relatively easy to identify and respond to. To them, however, must be added economic, political, philosophical and ethical concerns. These are much more difficult to evaluate and get agreement on because schemes for waste management and designs for disposal facilities inevitably incorporate, both consciously and subconsciously to varying degrees, economical, political, social and philosophical assumptions. For example, designs must respond to scenarios that incorporate assumptions about obligations to meet the problems associated with people who may intrude on the site at some point in the distant future, assumptions concerning the wishes and capabilities of future generations relative to waste management, and assumptions about the future of society as it is now understood. To get agreement among engineers or scientists on technological requirements is relatively easy; to get agreement across the spectrum of society on philosophical or ethical requirements is obviously a much more difficult task.

4.2 Waste management concepts

The Task Force was requested to design a process for the siting of a facility to dispose of low-level radioactive wastes. "Disposal," according to the AECB's regulatory document R-104 entitled "Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes – Long-Term Aspects," is "a permanent method of management in which there is no intention of retrieval and which, ideally, does not rely for its success on the continued need for institutional controls beyond a reasonable period of time."[10] The assumption is that the facility, once closed, could be safely abandoned without any constraint on the use of the land. The Task Force members discovered, however, that this long-term non-management concept is not universally accepted, even within the nuclear community.

The debate essentially concerns the distinction between storage and disposal. "Storage" involves the retrievability, monitoring, and ongoing institutional control of wastes. It also includes active elements of waste management in such a waste facility (e.g., leachate collection and treatment). By contrast, the concept of disposal assumes that a waste management facility can be designed in such a way that there will be no need for such measures.

More and more of the current literature on this subject and the Task Force's own assessment of this issue have come to support arguments favouring the concept of "long-term storage." This concept, a modified form of disposal, would involve placing wastes in a facility in such a way that active management would not be required, but that any migration of wastes from the facility could be monitored and, if necessary, as a remedial measure, material could be retrieved. The location of the facility itself would be permanently recorded and physically would not be "lost sight of" by future generations. In discussions with the public, the Task Force found that the concept of long-term storage is more supported than that of disposal. This is a result, in part, of doubts as to whether the technical knowledge yet exists to achieve effective disposal.

Another current point of debate concerns the importance of engineered barriers versus naturally occurring barriers in waste management facilities. In the past, a great deal of effort was spent in developing models to predict the capability of naturally occurring barriers to contain waste materials. Most of the shallow burial techniques currently in use rely on this approach. However, as a greater understanding of the true effectiveness of geological features to restrict waste migration has developed, reliance on naturally occurring barriers in waste management has been subject to more and more questions. Many surficial deposits that were thought to be homogeneous and impervious to water flow have turned out not to be. In addition, there has been a growth in knowledge about groundwater migration through bedrock which has resulted in a debate about how much emphasis should be placed on natural barriers in site selection, especially considering the effectiveness of engineered barriers that are now available. Their proponents argue that these barriers, unlike naturally occurring barriers, can be designed, constructed, tested and adjusted to suit the specific characteristics of the wastes which they are to contain and that they offer the potential for a greater degree of safety. Engineered barriers, such as those that use polymers and cement or that use special-property clays to enhance natural geological features, also allow greater flexibility in the siting of such facilities.

Regardless of the approach taken in the design of waste management facilities, safety must be the ultimate concern. Risk assessment studies have become the main means of determining the relative levels of safety associated with alternate designs. To carry out risk assessments requires the development and use of complex mathematical models. These mathematical models are all based on a number of assumptions that are derived from extrapolations of limited data sets. For example, to calculate the potential of clay to provide containment, assumptions must be made regarding the homogeneity of supposedly impervious clay layers. To find out whether a given clay deposit is in fact homogeneous, extensive drilling of the clay is required, an action which destroys its impermeability – its desired feature. Similarly, mathematical models have to be devised and assumptions have to be made when trying to determine the longevity of engineered barriers. Actual testing of such barriers can only be carried out in the relatively short time period of several years, even though design requirements call for structures that will need to exist for 500 to 10,000 years. Such problems with the use of models point out the need to exercise caution in their use and to make careful evaluations of their assumptions when carrying out risk assessments.

Risk assessment studies clearly have limitations. While risk models can be useful in development and selection of appropriate design options, complete faith in the validity of model projections is unjustified. Furthermore, it is important in facility design to incorporate proper contingency measures which allow for the possibility that design assumptions and model results may not remain valid for the estimated life cycle of the facility.

The importance of flexibility in approaches taken to waste management is underscored by the fact that perceptions of what constitutes proper management are constantly changing. For example, the objective of complete containment which guides facility design today was not present in the 1950s, when it was accepted that leaching would occur and the principal concern was to ensure that there was no one downstream. This was the approach taken when the Port Granby facility was established in 1955. However, this facility, and its predecessor at Welcome, incorporated a design criterion which had not been applied in earlier management practices, namely, that such facilities should ensure the separation of wastes from people. Earlier practices had involved the dumping of the wastes in landfill areas within the town of Port Hope. The Welcome and, subsequently, the Port Granby facility, situated in rural settings and designed for controlled access, established the desired principle of separation.

Although it is impossible to anticipate the shape of future developments in the field of waste management, nonetheless, it is important to note that changes will occur and provision for them must be made by using management approaches and facilities which employ as much design flexibility as practicable. This has implications for the notion that it is desirable to design waste management facilities in such a way that they do not rely on ongoing institutional controls. "Out of sight, out of mind" is not a viable approach, given that there may be a need, at some point in the future, to upgrade facilities in response to advances in knowledge and technology.

4.3 Technical options for a waste management facility

Various technologies have been developed for radioactive waste management. Some are already in use in several countries, including Canada, while others await testing.

To better understand the current experience and thinking in waste management techniques, the Task Force retained Acres International Limited (Acres) to document the technology options for low-level radioactive waste management that might be suitable for Ontario. The report produced, entitled "A Review of Low-Level Radioactive Waste Disposal Technology," serves as a background document to our report. The Acres study reviewed eight technical options and identified six approaches suitable for the management of low-level radioactive wastes. Each approach has advantages and disadvantages to be taken into account in determining its potential for use at any given site. Table 4, extracted from the Acres report, summarizes the relative merits of the eight waste management options which were examined and compared using eleven factors. Ocean disposal, disposal by injection, and emplacement of wastes in abandoned mines are not included in the table because Acres did not deem them to be suitable for Ontario's requirements. Present approaches to low-level radioactive waste management are based on four performance objectives: protection of the public; protection of workers at the facility; protection of intruders; and independence from long-term institutional control.

It is clear from the Acres study, as noted below, that there are several safe and suitable technical options for waste management. As a result, any approaches taken to the development of an appropriate facility for low-level radioactive waste management can retain needed technological flexibility and offer potential candidate communities a wide range of design choice.

Table 4

A qualitative ranking of concepts for disposal of all of Ontario's low-level radioactive wastes

	Uranium tailings	Aboveground vault	Trench	Belowground vault	Modular concrete canister	Borehole	Mined cavern	Abandoned mine
Public safety	*	C	C	B	B	B	A	B
Worker safety	C	B	A	B	B	B	C	C–
Intruder safety	*	B	C	B	B	B	A	B
Consequence of failure	A	B	B	B	B	B	A	A
Siting ease	C	A	B	B	B	B–	B	C
Retrievability ease	A	A	B	B	B+	B	C	C
Long-term predictability	C	B	B	B	B	B	B	C
Need for institutional control	*	C	B	B	B	B	A	A
Cost	A	C	B	B–	B–	B–	C	B–
Labour force size	A	C	B+	B	B	B	C	B
Community acceptance	B	B	B	B	B	B	A	A

A = most favorable
C = least favorable
* = see source for discussion

Source: Acres International Limited, 1987

The following sections outline technology options and demonstrate the range of possibilities available to potential communities. The Task Force members have determined that the broadest range of technical options should be kept open for the consideration by such communities.

Above-ground vault

Figure 8 outlines the above-ground vault option. Its main elements include:

- wastes disposed of above grade;
- an engineered concrete cover over the wastes;
- structural stability provided by the walls and cross-walls of the facility; and
- voids between containerized wastes filled with nonstructural material (bulk wastes are placed in the vault, uncompacted, by an enclosed-conveyor materials handling system through holes in the roof).

One major reason for building an above-ground vault is that it allows for constant surveillance. However, the main difficulty with the above-ground vault is that many of Ontario's low-level radioactive wastes are long-lived; thus, the facility would require thousands of years of surveillance. Since any such facility would be exposed to the elements, natural decay would be a problem and constant maintenance would be required. However, being at or above ground, it would be relatively straightforward to determine the need for maintenance and to undertake it as required.

There is no such facility currently in operation.

Figure 8

Illustration of an above-ground vault (Acres International Limited, 1987)

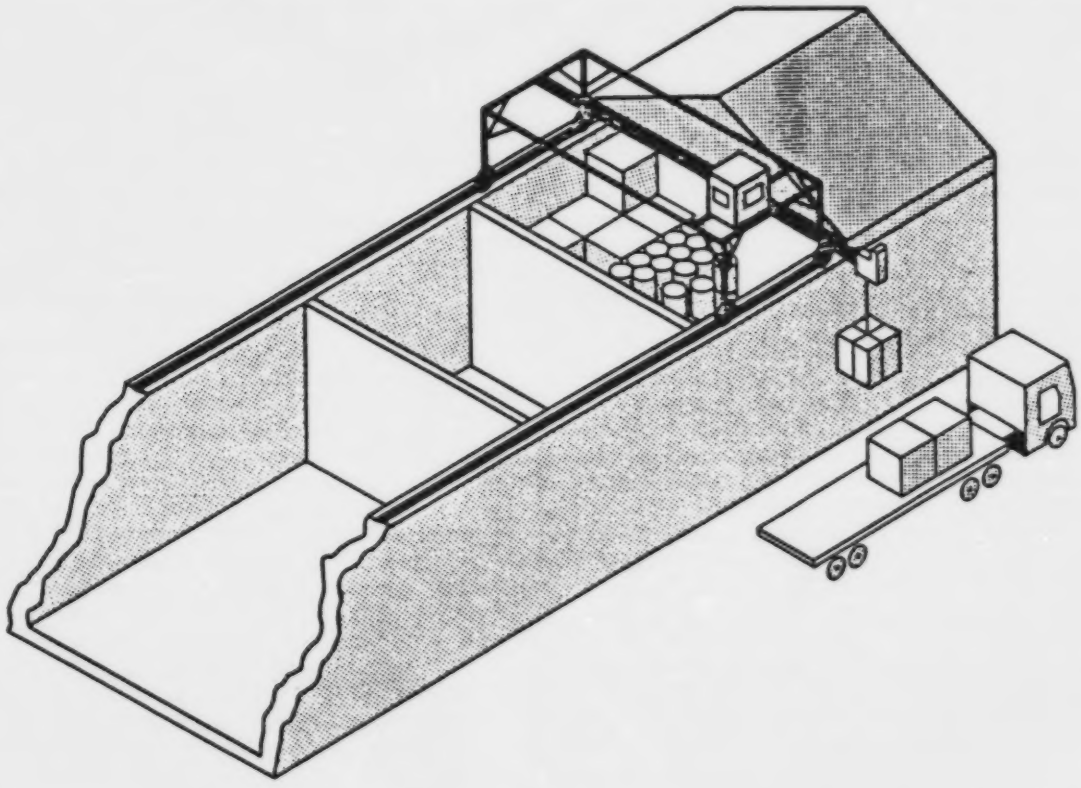
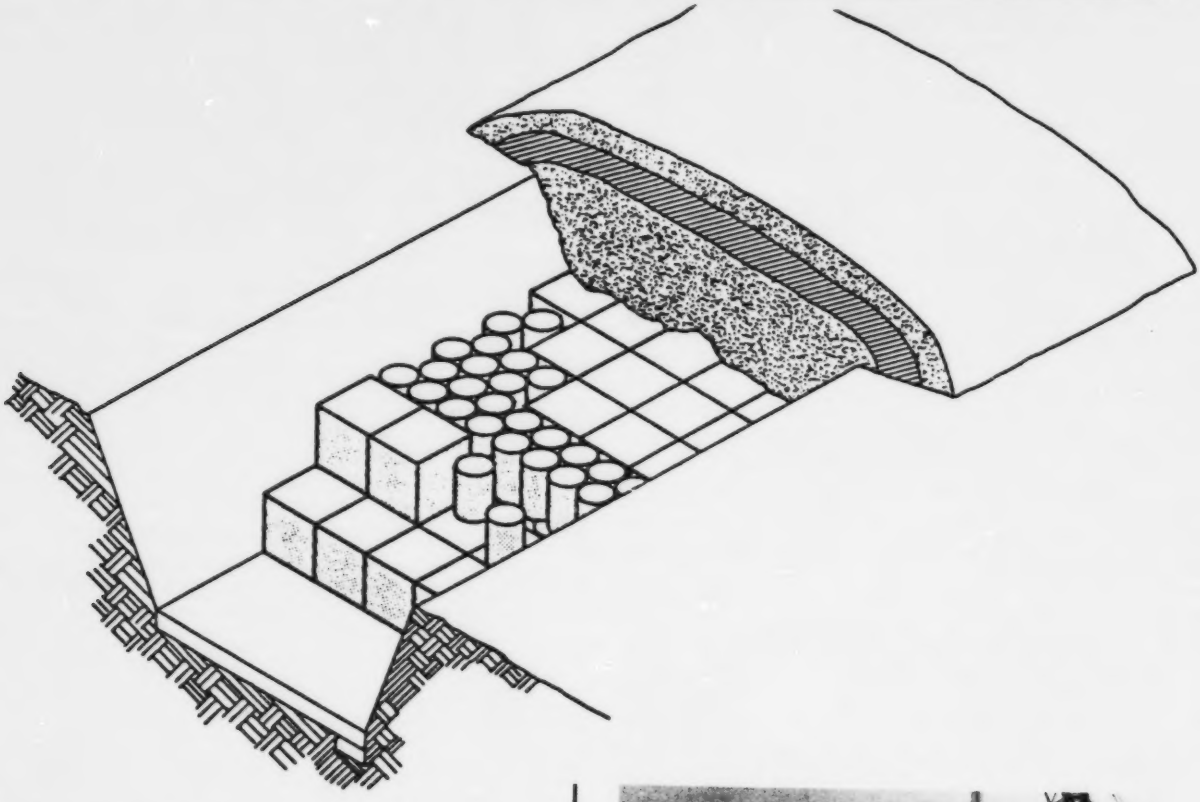


Figure 9

Illustration of a shallow land burial facility (engineered trench) (Acres International Limited, 1987)



Engineered trenches

Figure 9 outlines the engineered trench option. In this option, the major characteristics are that:

- wastes are placed below grade (in suitable hydrogeological conditions) in trenches having a specially prepared bottom that incorporates a drainage system;
- there is an earthen cover over the wastes that easily can incorporate additional engineered barriers;
- structural stability is not provided by the disposal facility; and
- for structural stability, voids between the waste containers are filled with sand or earthen materials – bulk wastes may be compacted.

Wastes with higher radiation fields, high specific activity, or long-lived nuclides, are placed at the bottom of the trench. Additional engineered barriers can be adapted to this option and it is well-suited to large volumes of low-level radioactive wastes. However, surveillance is difficult and future remedial work would be a problem.

Container placement in waste management facility at Barnwell, South Carolina

The Chem Nuclear facility in Barnwell, South Carolina is an example of engineered trenches which rely on natural containment.

Below-ground vaults

In the below-ground vault option (Figure 10), the major characteristics are that:

- wastes are placed below grade in a reinforced-concrete vault in a suitable hydrogeological site;
- the vault is covered with a thick concrete roof, covered in turn by a thick layer of earth;
- structural stability is provided by the facility itself;
- the voids between the waste packages may be filled with sand or the wastes may be compacted by heavy equipment; and
- no additional engineered barriers are required.

The main advantage of such vaults is that the concrete, being below ground, would be less vulnerable to environmental factors. The structure would provide good protection from intruders. However, it would be difficult to monitor leakage and undertake future remedial work.

No such vault is currently in operation. However, one is planned for the Chalk River Nuclear Laboratory.

Modular concrete canister disposal

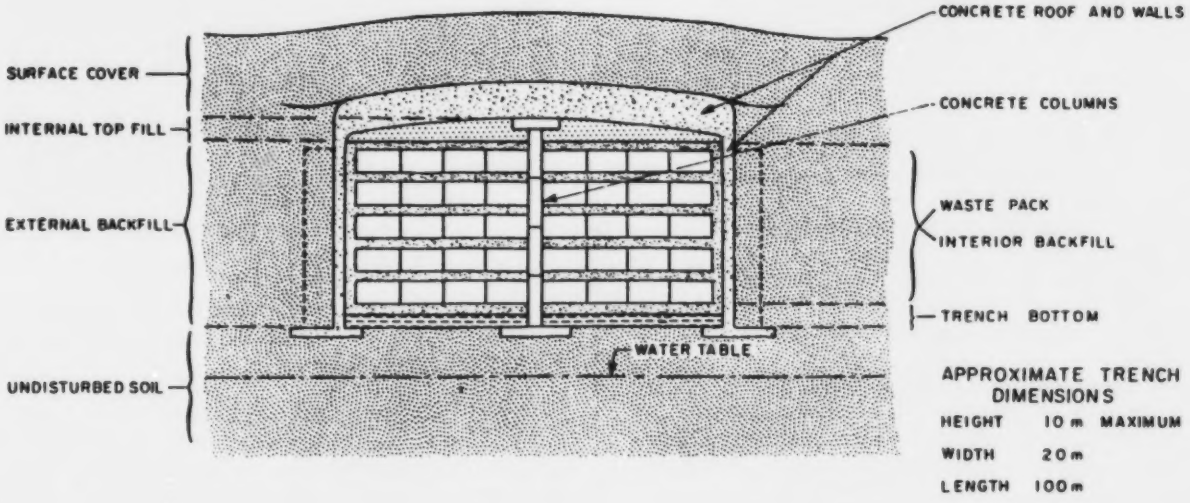
Figure 11 shows the canister disposal option. Its main characteristics are that:

- wastes are placed in concrete canisters that can then be placed either in shallow, below-grade trenches or above grade on a concrete pad;
- there is a shallow earthen cover over the waste trenches containing the canisters (earth or soil may be mounded over the canisters in the above-ground version);
- structural stability is provided by each canister;
- the structure is modular in nature; and
- safety may be enhanced in future by additional engineered barriers.

The canisters for this option are shaped to fit together, reducing space requirements and providing support to the facility. Also, since each canister is discrete, the possibility of large-scale rupture is minimized and retrievability is facilitated. However, the cost may be a disadvantage where large volumes of low-level radioactive waste are involved, given the added expense of individual concrete containers. For storage of a sizeable volume of waste, the canister size could be increased somewhat beyond the dimensions of canisters being designed today (generally two metres in diameter by two metres high) to achieve better economies. However, the design must ensure that the integrity of the canisters is maintained, and that the canisters can be moved and/or retrieved, if necessary. In addition, there is the problem of higher worker exposure that results from

Figure 10

Illustration of a below-ground vault after closure (Acres International Limited, 1987)

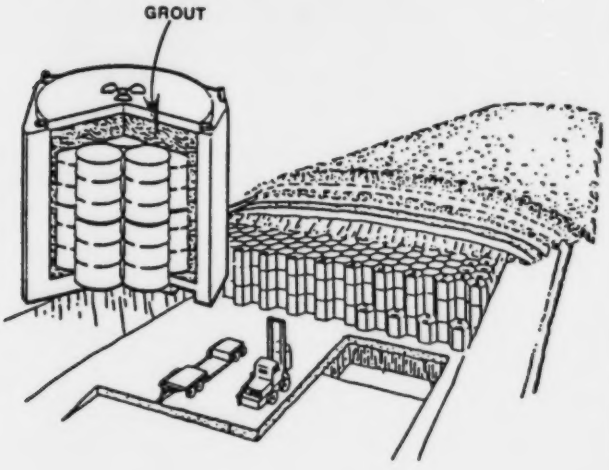


the extra waste handling required during canister-loading operations. This is offset somewhat by the fact that in the event that the waste must be retrieved at some time in the future, the canisters offer protection from radiation exposure while the waste is being handled, assuming of course, that canisters are designed to withstand the rigors imposed by time.

Although the canister option is not currently in use anywhere, one group in the United States is giving it serious consideration.

Figure 11

Illustration of a modular concrete canister disposal facility and canister (Acres International Limited, 1987)



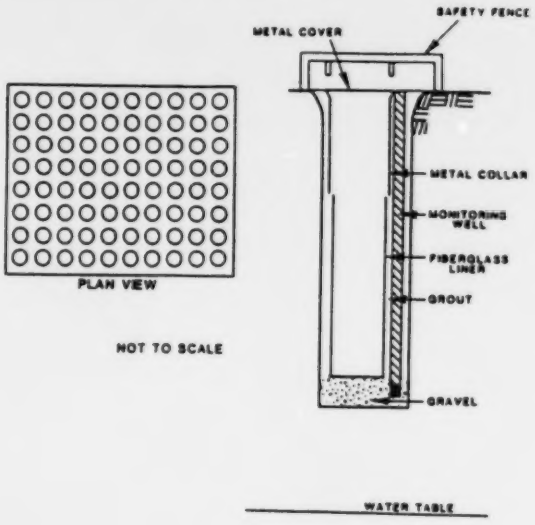
Boreholes

Figure 12 outlines the boreholes option. In this method:

- wastes are placed below-grade in concrete "pipes";
- a deep cover of soil or concrete is placed over the wastes and is then capped by a steel cover;
- structural stability is provided by the concrete disposal units; and
- the voids between the waste containers are filled with soil.

Figure 12

Illustration of an augered hole low-level waste disposal facility (Acres International Limited, 1987)



Good protection from intruders, resistance to environmental wear, and retrievability make this an appealing option. However, this method appears best suited to low volumes of higher activity wastes and, thus, is not practical for large volumes of low-activity wastes (e.g., Classes 0,I). It may be very suitable for Class II and III wastes, with their substantially smaller volumes.

Boreholes at Ontario Hydro's Bruce Nuclear Power Development

Mined Caverns

The major characteristics of the mined caverns option, illustrated in Figure 13, are that:

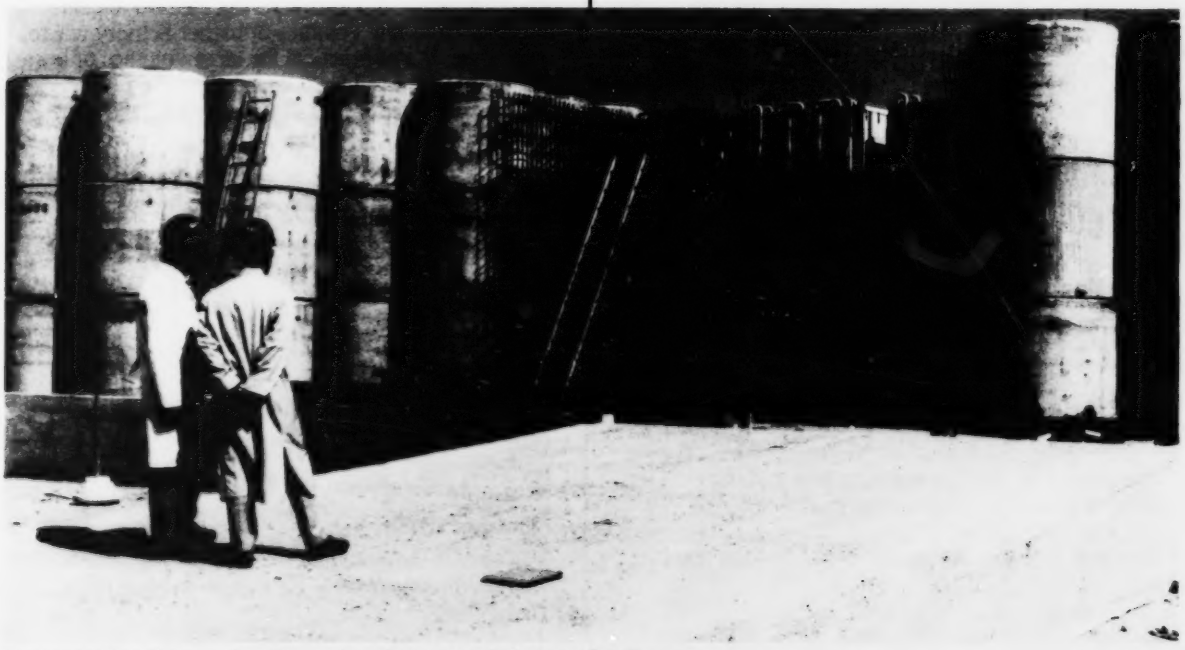
- wastes are placed in excavated rock cavities which have low ground-water flow, a definable structure and good rock competence;
- there is a deep cover over the waste;
- structural stability is provided by the host rock; and
- wastes may be disposed of in packaged or bulk form, depending on cavern design.

While the risk of worker exposure to radiation under this option is well below safety norms, there is considerable occupational hazard related to the mining operations themselves. Monitoring, remedial action and waste retrievability are not readily feasible with this option. As well, most candidate locations for such rock cavities are below the water table. Thus, even if groundwater flows are small, the wastes will eventually be flooded.

Technological variations

Of course, there are numerous possible variations of these six options which could be employed for low-level radioactive waste management, such as: above-ground vaults that are covered with a mounded earthen top, (i.e., a tumulus); modular concrete canisters used as above-ground vaults (that could also be mounded); and use of more than one disposal concept at one site to provide for management of wastes according to their activity level and volume.

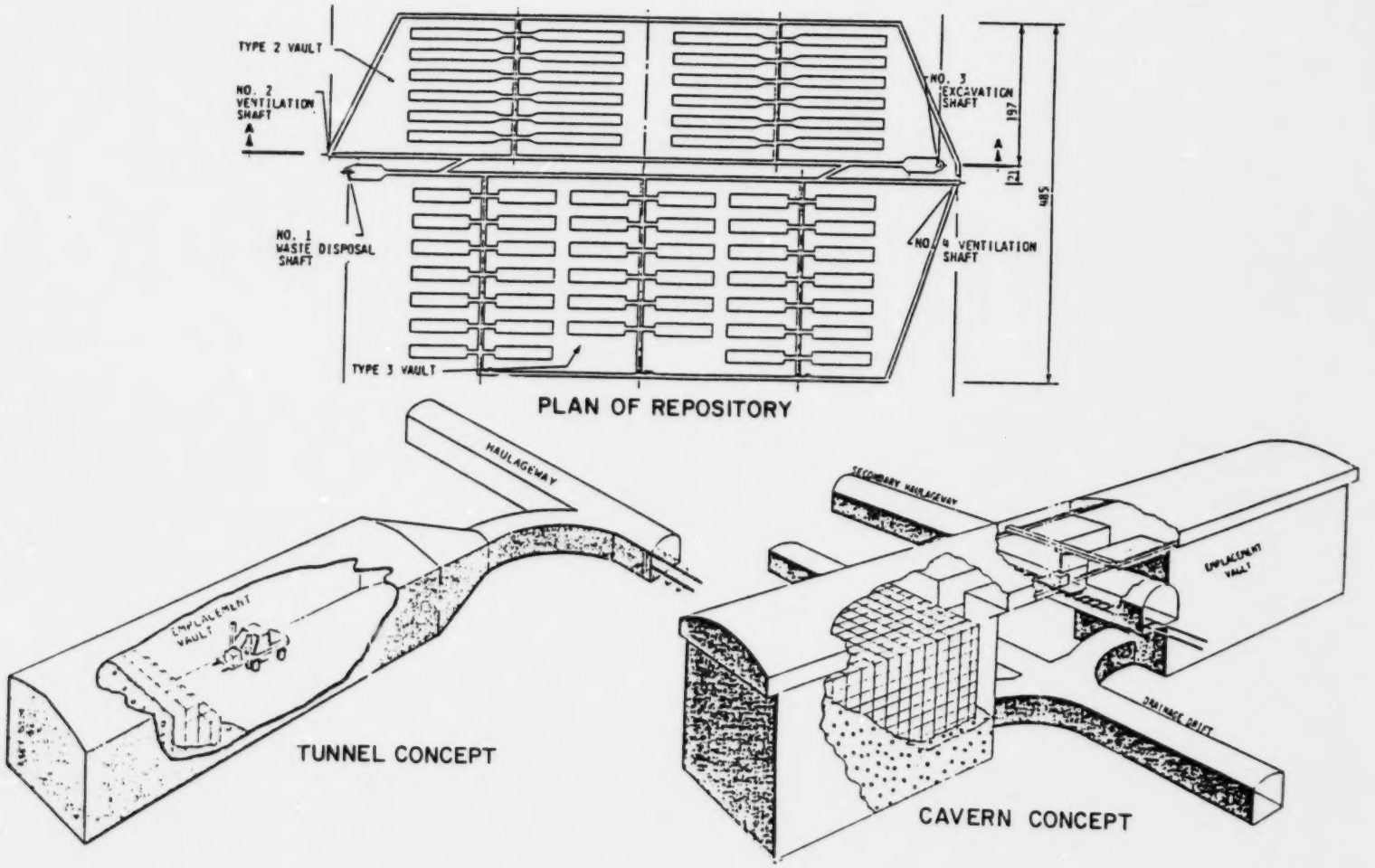
In addition, there are important geological and hydrogeological requirements for each of the waste management options that are not unique to each option. For example, the above-ground vault is not geology-dependent and could be situated almost anywhere in Ontario. However, monitoring requirements will dictate that it be placed on uniform material where monitoring can be accommodated. Mined cavities may also be constructed on a range of geological formations including Precambrian shield and dolomitic limestone, as well as some shales. The engineered trench, below-ground vault, modular concrete canister and borehole methods have similar geology requirements. For these options, a relatively uniform overburden of clay, till or sand is preferred – a soil type frequently found in Southern Ontario. In the final analysis, site-specific investigations must be performed to determine the suitability of any given site for a given technology option.



In preparation for tumulus disposal at the Centre de la Manche, France.

Figure 13

Illustration of a conceptual mined cavern disposal facility (Acres International Limited, 1987)



4.4 The need for improved management

The AECB order to Eldorado Resources Limited to develop plans to decommission its Port Granby site, and AECL's intention to remove contaminated soil from a Scarborough site, both imply the need for better management of at least these two Ontario deposits of low-level radioactive waste. Various AECB publications, Task Force interviews with AECB and other officials, and the Task Force's terms of reference all suggest that improved management may be required at some of the other sites in the province. However, what is not clear is the specific nature of the problems underlying calls for improved management. Do all or any of these sites pose a threat to human health and the environment? To what extent do they need to be improved?

It is difficult in logic or in conscience to propose a solution before the problem has been fully defined. It is even more difficult when that solution promises to be extremely expensive and disruptive. In this case, it is essential to understand the problem that low-level radioactive wastes pose now and in the future so that management objectives can be identified and the appropriate means to achieve these objectives can be devised and put in place.

For this reason, the Task Force asked the various federal and provincial government agencies with responsibility, either direct or indirect, for ensuring the safe management of such wastes to give their opinions on the relative hazard of each site in Ontario. The agencies contacted were the Board (as the regulatory agency with statutory authority for control of all aspects of the safe management of radioactive materials) and the Board's environmental and medical advisors – the Department of the Environment (DOE), National Health and Welfare (NH&W) and the Ontario Ministry of the Environment (MOE).

Task Force members requested from each agency a precise numerical assessment and prioritization of the threat posed to human health and to the environment by each of the accumulations of low-level radioactive wastes in Ontario, including the threat posed by the non-radioactive contaminants of the radioactive wastes where these existed. (See Appendix F.)

Summaries of the responses from AECB, DOE, NH&W and MOE follow. Their full replies are reproduced in Appendix G.

Correspondence with the regulatory agencies

AECB's Reply

The Atomic Energy Control Board excused itself from comment on those waste accumulations which it did not license or of which it has little knowledge. This eliminated the phosphogypsum wastes and the wastes at Deloro from consideration, but did include the uranium mine and mill tailings and the Port Hope and Scarborough wastes. The AECB listed an extensive number of technical factors which should be taken into account in assessing the risk to human health and/or the environment, stressing that these are given no kind of ranking as to relative importance. These factors are reproduced here for information.

Waste characteristics:

- Bulk physical and chemical properties of the waste.
- Inventory of particular radionuclides and other contaminants and the longevity of the radioactive contaminants.
- Average specific activity (radioactivity per unit volume or weight). Care must be exercised in the use of this index inasmuch as "hot spots" may exist within the larger body of waste.
- Physical, chemical, biological and other processes taking place within the waste itself.

Characteristics of storage environment:

- Geology, hydrology, meteorology and topography of the site.
- Existence/necessity of engineered works to contain the waste.
- Existence of natural geological barriers to movement of contaminants.
- Existence of physical, chemical, biological and other processes which inhibit movement of contaminants.
- Is the site adequately monitored?
- If monitoring is needed, can an efficacious monitoring program in fact be implemented?
- What is happening at the waste site (i.e., within the waste itself and within the surrounding environment) and how good is our understanding?
- If our present knowledge is inadequate, is it possible to acquire the required detail (may represent economic trade-off with disposal of the waste)?
- Impact of the natural environment (physical, chemical, biological, geological, hydrological, meteorological) on the storage site, especially in the long term.

- Possibility of changes in the natural environmental processes over time (both beneficial as well as deleterious).
- Are remedial measures necessary to ensure stability of the site and containment of the waste (may represent economic trade-off with disposal of the waste)?
- Are adequate contingency plans in place to deal with the possibility of a gross breach of containment?

Separation of people and waste:
- How mobile are the contaminants within the waste itself?
- By what mechanism can the contaminants escape containment and what probability is attached to each of these possible mechanisms?
- Are any of these processes synergistic?
- What impact (radiological and otherwise) will escaping wastes have on man and the environment in both the short term and long term (i.e., do contaminants enter the general environment slowly and in acceptably dilute concentrations)?
- Can the general public gain access (inadvertently or otherwise) to the waste (i.e., the intrusion scenario)?
- Are institutional controls (e.g., monitoring, treatment of effluents, operation and maintenance of all systems, access control) necessary to ensure the continued separation of people and waste? This is the case at all waste storage sites now licensed by the AECB.
- If institutional controls are necessary, is there a reliable and stable organization which will accept responsibility for the waste for as long as it remains a hazard?

The AECB also stressed that the present management at each of the low-level radioactive waste accumulation sites that it licenses is well within the limits set by the licence conditions and that, in its judgement, the risks posed by any emissions from these sites are less than those it deems acceptable. It should be noted, however, that the Board issues management licences to only five sites: the Bruce Nuclear Power Development, the Chalk River Nuclear Laboratory, the Welcome site, the Port Granby site and the Hawker Siddeley Canada Ltd. plant in Mississauga. In addition, the Board also licenses the management of uranium mine tailings during the period of ore removal and decommissioning.

To quote from the Board's submission:

> All waste facilities presently subject to an AECB licence meet the requirements of that licence and in general keep effluent releases well below regulatory limits in accordance with the principle of limiting radiation exposure to as low as reasonably achievable. The risk of any licensed facility is, therefore, something less than the risk associated with the radiation dose limitations in the Regulations.

Accordingly, the need for improved management of low-level radioactive wastes in Ontario does not derive from any apparent health or environmental risk that is now posed by the licensed wastes since emissions are well within the Board's standards. Rather, the imperative for improved management comes from the Board's concern for the longer-term acceptability of current waste management methods.

Each licensed waste site requires continual surveillance and some require periodic remedial action to keep the site secure and ensure that risks remain at an acceptable level. It is this ongoing need for institutional control that concerns the Board. The licensed wastes, as currently managed, are an ongoing "problem." The AECB prefers long-term management entirely free from the need for institutional control and monitoring, although this view might be tempered if the federal government accepted long-term responsibility for institutional control. The Board acknowledges, however, that complete disposal may not be possible and that it may be necessary to accept some measure of institutional control. In this regard, the Board stated that Ontario Hydro's approach to the storage of low-level radioactive wastes at the Bruce Nuclear Power Development site is exemplary and that wastes there can be managed in this way until completely decayed.

Overall, in assessing the need to improve on current waste management methods, the Board appears to apply two criteria: the extent to which waste management practices satisfy the requirements of disposal and, failing this, the extent to which the approach to storage measures up to Ontario Hydro's management practices. Consequently, the Board groups low-level radioactive waste accumulations in the province into three categories according to the degree of priority that it attaches to their need for improved management:

- High priority deposits
  - Town of Port Hope;
  - Port Granby site; and
  - abandoned uranium mine tailings.

- Medium priority deposits
  - Welcome Waste Management Facility; and
  - Chalk River Nuclear Laboratories.
- Low priority
  - Scarborough;
  - Masterloy Products Limited (Ottawa);
  - Exolon Company of Canada (Thorold);
  - Chromasco Limited (Haley Station);
  - Norton Research Corporation (Niagara Falls);
  - Hawker Siddeley Canada Limited (Mississauga);
  - Haley Industries Limited (Haley);
  - Walker Brothers Quarries Limited (Thorold); and
  - Bruce Nuclear Power Development.

The Task Force members have noted that there are inconsistencies in the Board's approach to management of low-level radioactive wastes. For example, in the case of the Masterloy company, the Board issued a licence "principally in order to control the disposition of the waste." The Board now indicates dissatisfaction with intermediate and long-term management of these wastes. Nevertheless, it allowed the original licence to expire and has not replaced it with a waste management licence. Thus, the Board lost control and ongoing knowledge of the situation.

The case of the Exolon Company is similar, except that here the Board indicated a more immediate concern about residential development encroaching on the site. As in the previous case, the Board allowed the licence to expire without first ensuring that some other authority would take over control and apparently without ensuring that those with authority over land use and development were aware of, or would take action on, the Board's concerns over urban encroachment on the sites. These examples also raise the issues concerning the responsibilities of local authorities in the safe management of low-level radioactive wastes.

The reply from National Health and Welfare

The full response from the Bureau of Radiation and Medical Devices at NH&W is attached as part of Appendix G. It proved to be of no use to the Task Force, even though the Task Force had anticipated that there would be information readily available from this source. However, the reply which states, "I regret that we will be unable to provide you with this information. I am afraid that even a qualitative ranking of the different sites would not be possible without many person-years of work . . .," indicates that this was not the case.

The reply from the Department of the Environment

In its reply, DOE acknowledges its role as advisor to the Board but points out that its mandate does not extend to incidental wastes. The response and one of its attachments (reproduced in full in Appendix G) describe in very general terms the approach taken by DOE to define the hazards of wastes. The Department has provided a relatively comprehensive list of the factors to be taken into consideration when conducting landfill site selection for hazardous waste.

The brief's comments on individual low-level radioactive waste deposits do not provide any numerical estimate of risk and give very little information which was not already present in greater detail in the Inventory sent to DOE by the Task Force.

DOE drew the attention of the Task Force to a document produced by a joint DOE/MOE (Ontario) team entitled "Port Hope Harbour - Remedial Action Plan Status Report."[11] This document, dated April 1987, provides a detailed timetable which proposes that a final Remedial Action Plan, involving removal of the sediment from the harbour, be transmitted to the International Joint Commission by December 1989.

The document describes the contamination of the sediments of Port Hope harbour with various radionuclides and potentially toxic heavy metals. It shows that much of the present public concern is unfounded as levels of radionuclides in fish caught in the turning basin are so low that their consumption by the general public is unrestricted. A previous survey in 1968, which found toxic levels of copper in the sediment, was not confirmed by a more recent survey (1984). Surprisingly, data on levels of radioactive and non-radioactive contaminants in the water of the harbour or turning basin are nowhere to be found and not a single radiation measurement is given. It is stated that no data are available concerning bioavailability of contaminants in the harbour.

The report notes that the inability to dredge the turning basin (presumably because of the absence of a site to dispose of the dredged material) will eventually cause the basin to silt up, thus rendering it useless as a mooring for boats. This is the only specific threat to human health or happiness mentioned in the document.

DOE has indicated that, by December 1987, data will be available indicating uranium and thorium levels in Great Lakes fish and Ganaraska River sport fish, and that a fish sampling program will be initiated to measure non-radioactive elements in turning basin fish. The data base is due to be updated at about the same time with other toxicity studies.

The reply from the Ontario Ministry of the Environment

The Ministry of the Environment of Ontario stated that the issues on which the Task Force requested comment are "essentially the responsibility of the federal government." MOE provided Task Force members with no risk assessments because these are the "responsibility of the Ministry of Labour." MOE's response is attached in full in Appendix G.

MOE made specific comments on uranium mine tailings, certain incidental wastes and wastes from nuclear energy and radioisotope production and use. In the case of the last item, MOE again emphasized federal responsibility and acknowledged that wastes are received at Chalk River, for a fee, from radioisotope users across Canada.

In the case of mine tailings, MOE made reference to a water reading alleged to exceed marginally the National Health and Welfare standard of 0.1Bq per Litre for Radium 226. The mounds of phosphogypsum wastes were said to have radiation readings below the allowable limit "at waist height." In all instances, the concern was related to unrestricted or insecure access and improved management; there was no serious attempt to assess the present threat to human health or the environment in numerical terms. Nevertheless, MOE stated more than once that there is an urgent need for a low-level radioactive waste management site for all of Ontario. It expressed the view that the soil contamination problem in Scarborough could have been mitigated had there been such a site available. The Ministry made no mention of the Deloro site which the Task Force understood to be a provincial responsibility.

The management imperative

From the statements of these federal and provincial agencies, there appears to be no serious, immediate threat to human health or the environment from the Port Hope wastes or any other low-level radioactive waste accumulations in Ontario. However, it is clear that at some sites, (e.g., the Bruce Nuclear Power Development and the Chalk River Nuclear Laboratory), a significant threat could exist if for any reason institutional management at current standards were to break down. At sites to which access is unrestricted (e.g., abandoned mine tailings and certain sites in Port Hope), it is possible for an intruder to be exposed to radiation dose rates which, if continued for a long period, could lead to negative health effects. As well, erosion of some of the uncontrolled sites could lead to dispersion of some of the radioactive material that is now relatively confined, although it is by no means certain that this would lead to a threat to health or the environment.

Any technical assessment of implications for human health and the environment requires an objective base that goes beyond initial concerns which naturally are evoked by the suggestion of possible leakages of radioactive material into Lake Ontario or any other body of water. Yet, studies to date do not establish well-defined risks. For example, a recent report revealed no dangerous concentrations of radioactive materials in the fish of the Port Hope turning basin or of any evidence that the existing concentration is rising (Port Hope Harbour Remedial Action Plan Status Report). In the absence of such defined risks, the only imperative for action in Port Hope, and in other locations where there are low-level radioactive waste accumulations, is to improve existing management practices.

What is incontrovertible is that there exist, in Port Hope and other areas, sites in which low-level radioactive wastes have been deposited in a poorly planned fashion and which do not offer the degree of security that is both possible and desirable. A substantial improvement in management, through a variety of technological alternatives and administrative measures, is warranted. This then raises the obvious question: what specific kinds of improvements should be undertaken?

4.5 The need to reassess management options

The AECB has embraced the principle of permanent disposal as the ultimate acceptable means of long-term management of low-level radioactive wastes. This is clearly set out in its recent regulatory document, R-104.

As noted, the Task Force members believe that the underlying arguments for this objective do not necessarily lead to a permanent disposal conclusion. For instance, the International Commission on Radiation Protection (ICRP) principles for waste disposal, and indeed the AECB's, include the possibility of alternate methods to permanent disposal. Furthermore, as discovered in the Task Force's discussions, the permanent disposal option may not be acceptable to elected officials and the public that they represent.

The Task Force believes that permanent disposal, as encouraged by the Board, may not always be necessary or desirable even for those wastes which might be moved from their present locations and managed in a central facility. The worst feature of being committed to the permanent disposal solution is that it effectively prevents all progress on practicable and achievable steps to improve management, while focussing on a distant and perhaps unachievable goal. It appears that simple, practical and inexpensive measures to improve management of low-level radioactive waste could be denied merely because they fall short of a perfect, ultimate solution. In managing most practical problems, including problems of industrial pollution (of which low-level radioactive waste is one example), it is normal to employ much more pragmatic approaches. Indeed, significant improvements in management, or reductions in pollution levels are regarded as worthwhile, at least as interim steps.

Task Force members see no reason why the pragmatic approach adopted for analogous problems should not apply to low-level radioactive waste management. Members find it unusual that potential expenditures of hundreds of millions of dollars to remove and house low-level radioactive wastes are being seriously contemplated, presumably because of the danger posed by the wastes, while the agencies responsible have not demonstrated that the existing low-level radioactive waste management sites pose a serious threat to human health or the environment.

Furthermore, no serious attempt has been made to restrict the public from access to some of the sites in the Port Hope area or, similarly, from locations housing uranium mine and mill tailings elsewhere in the province. Such an inconsistent approach to the management of low-level radioactive waste accumulations is likely to cause confusion. Additionally, it may unjustifiably reduce the credibility of waste producers and the regulators in the eyes of the public in cases where the management approach taken was entirely appropriate and responsible. In the final analysis, the Task Force must conclude that the prolonged debate over the perfect waste management solution has only been possible because there is currently no urgent threat to health or the environment.

While everyone generally agrees that there is a need for improved management of low-level radioactive wastes, there is no comprehensive community-based study that assesses the management requirements for each of the existing waste accumulations. The Task Force members feel that such studies are essential and must be undertaken. Further, they feel that the phrase, "improved management," needs to be defined in clear and precise terms. As well, each existing waste accumulation site must be assessed on its own merits to identify the specific management measures that could apply. This site assessment process must involve consultation with the local community to ensure that people are fully informed about potential impacts and that their concerns and preferences are made known. In addition, it must be recognized that efforts to improve the management of low-level radioactive wastes throughout the province will have impacts on each community in which the wastes are currently located, the community in which the new facility will be sited, and, of course, the communities along waste transportation routes. The waste management process must be responsive to all the concerns. Therefore, each waste accumulation site should be assessed according to the specific local problems and, where appropriate, the waste producers should be involved in the process.

In addition to greater consultation, there also must be greater flexibility by control agencies like the Board in terms of what is or is not an acceptable starting point for waste management. If the fundamental principle guiding management is only permanent disposal, then options for waste management will be very limited since all management solutions must meet the safety and environmental standards set out by regulatory authorities. For example, considerations of such factors as volume, the disruption which removal might cause, costs and local preferences may make long-term management in situ a practical option for some of the existing wastes. The Task Force feels the uranium mine and mill tailings and the phosphogypsum wastes are best dealt with in this manner and that in situ management should at least be considered for several other waste deposits, including some in the Port Hope area.

Even with an in situ option being exercised, it is probable that a single new major (large volume) facility would still be required, at least for the Port Granby wastes. This results from the large-scale engineering works that are needed on the present site to prevent erosion and the lack of capacity of the present site to take ongoing Eldorado waste for more than approximately the next three years. There is no health or environment imperative to indicate in what part of Ontario the new facility should be located. It would appear sensible to design it to be able to manage the existing Port Granby wastes, the ongoing wastes from Eldorado, AECL, Ontario Hydro and others (some of which are Class I, II, and III wastes), plus those parts of the existing wastes from elsewhere in the province that require relocation for better management.

The Task Force members urge the use of an approach that has "improved management" as its objective, rather than pursuit of the universal goal of disposal without the need for institutional control. The Task Force members have developed a facility siting process that, if successful, would result in the construction and operation of a central radioactive waste management facility to handle those parts of the radioactive wastes which are judged to be appropriate.

Regardless of actions taken to improve management of existing waste accumulations, communities involved should be provided with a definitive statement from the Atomic Energy Control Board which certifies that the management activity undertaken provides effective protection to residents.

4.6 Cost considerations

It was pointed out earlier that in raising issues pertaining to facility siting, the general public will tend to emphasize the environmental and social costs to be considered. While it is natural and essential that these basic human values – the concern for a safe environment and maximized social well-being – will figure prominently in the debates surrounding low-level radioactive waste management, no complete analysis can overlook the economics involved in any proposed solutions. Accordingly, the Task Force commissioned two cost studies to identify the major cost parameters involved in low-level radioactive waste management in Ontario. The first cost analysis discussed is titled, "Assessment of Costs Associated with Construction of Low-level Radioactive Waste Disposal Facilities"; it is an appendix to the Acres' review of disposal technology options, referenced earlier. The second cost assessment, also noted earlier, is titled "Regulatory Issues and a Preliminary Study of the Costs Associated with Transporting Low-level Radioactive Waste Out of the Port Hope Area." These two background reports will hereinafter be referred to as the "Facility Cost Study" and the "Transportation Cost Study," respectively.

Before the costs of any low-level radioactive waste management project for Ontario can be clearly estimated, the scope of the project must be defined. This involves the determination of a number of factors including:

- the clean-up criteria established for existing waste accumulations and the total waste volume to be located in the new facility;
- the defined scale of the facility;
- the distances to be covered in transporting the wastes from possible sources to the ultimate destination;
- the transportation option(s) used;
- the characteristics of the wastes and, by extension, their handling requirements;
- the proportion of total project costs to be budgeted for impact management; and
- the extent of any engineered barriers incorporated into the technological design of the facility.

Although costs for some of the variables listed could not be ascertained, the studies established cost guidelines for the two major components of overall project costs. These two are the costs of the facility itself, and the transportation and related infrastructure costs. Because neither the volume or location of wastes to be handled by the facility, nor the distance over which the wastes are to be transported is defined, some limiting assumptions were incorporated into the estimates generated in the two studies. For example, for the purposes of both studies, wastes from the Port Hope area only were used to arrive at the estimates. In addition, the assumption was made that the total volume of these wastes (i.e., 880,000 cubic metres) would be relocated. These two studies provided the Task Force with an example of the range of costs that might be expected to result from implementation of one form of improved waste management. It must be stressed, however, that the costs arrived at in these studies constitute merely one scenario that could become more or less expensive as wastes from other sources are included, as waste volumes to be relocated are changed, or as transportation and other factors mentioned in the factor list are adjusted.

Waste management facility costs

The Facility Cost Study was a comparative overview with general cost estimates of several facility designs, some tested and some untried. Estimated costs were calculated for five designs. Estimates outlined the capital and operating costs for each phase of project implementation. The phases considered included: pre-operational; operational; closure; and post-closure.

To establish a consistent basis for cost analysis and comparison, with respect to the technology options, several specific assumptions were made. It was assumed that the wastes would primarily be contaminated soils or similar material that could be handled by bulk material handling techniques without the requirement for "packaging." The facility would be designed to store 880,000 cubic metres of waste. As well, cost projections were based on an assumed inflation rate of five percent and assumed interest charges for financing of ten percent. It was also estimated that the accumulated debt for the facility would be paid off at the end of operating period. In regard to the scheduling of the phases to establish the proposed facility, study assumptions were for a two-year pre-operational period, five years of operation, one year for closure and 50 years of institutional control.

The study also used the assumption that certain parts of the disposal facility, as well as labour and land requirements for these components, would be common to all the five disposal methods examined in detail. Among common elements included were the support facilities in all technical options (i.e., guard house, water retention ponds, laboratories, container transfer building and a storage area) and the cost of lands to house each facility.

Clearly, all these costs would vary according to the volume of wastes actually to be stored. It should also be stressed that the facility costs were based on very specific designs, which could be altered in numerous ways which, in turn, would have an effect on the facility costs.

Not surprisingly, what is evident from Table 5 is that costs increase commensurate with the degree of engineered barriers or safeguards built into the design. Equally true, the added advantages of waste retrievability in certain design features command a higher cost.

Table 5

Waste management facility costs

(based on volume totalling 880,000 m^3)

Technology option	Basic total facility cost
Engineered trenches	$215.6 million
Above ground vaults	$310.6 million
Below ground vaults	$453.1 million
Modular concrete canisters	$384.5 million*
Mined caverns	$484.1 million

*This figure was based on a facility that would use non-standard canisters, 10 metres in diameter by 10 metres high. These larger containers were suggested to achieve some economies of scale in emplacing the inordinately large volume of waste specified in the example. If the more standard-sized canisters (2 metres in diameter by 2 metres high) were used for an operation of this scale, the cost for the facility would soar to $540 million.

Transportation costs and legislative framework
The Transportation Cost Study was an analysis of possible transportation costs. Estimates were made using the removal of all of the wastes from the Port Hope area as an example. As well, to take full account of the transportation costs involved in a waste removal operation of this nature, pertinent legislation was researched to determine which regulatory requirements if any might increase forecast costs.

There are a number of statutes governing the transportation of dangerous goods at both the provincial and federal level. Because of concerted efforts made by these two tiers of government to rationalize the regulations, there is virtually no overlap of requirements or jurisdictions. Transportation safeguards stipulated in the legislation – safety measures such as placarding, special packaging and carrier decontamination – constitute only nominal cost increases when compared to basic transportation costs.

The review of the legislation brought a number of issues to light with respect to the transportation of the wastes located in the Port Hope area. Most importantly, a significant portion of the wastes (some estimates go as high as 60 percent) falls below the defined minimum for "radioactive material." Therefore, for transportation purposes, these wastes need not be considered radioactive. Technically, no special precautions are required for their transportation. However, realistically, the segregation of the wastes into "radioactive" and "non-radioactive" material would involve too much handling, and thus expense, to be undertaken. Therefore, assuming that the wastes would not be segregated, they would all be treated as low specific activity material. This category is part of the existing waste classification system in Canada, which is detailed in the Transport Packaging of Radioactive Materials Regulations, made pursuant to the Atomic Energy Control Act.[12] In this case, regulatory authorities hold the opinion that transportation of the waste in bulk, in lined containers with lids or covers to prevent spillage or dispersion, would meet safety requirements. They also state that regardless of the transport mode chosen, appropriate radiation protection and monitoring programs would be required to assure the protection of workers and the public. Allowances also would have to be made for material that exceeds the acceptable radiation level for low specific activity, involving special packaging and other special transportation actions.

In assessing routes to use for trucking the wastes, the question arose as to whether municipalities might impose load-restriction by-laws for municipal roads to bar the truck traffic from densely populated areas. In such a case, there could be additional costs to build alternate roads. However, the Task Force discovered that such restrictions cannot be imposed without prior approval from the Ontario Ministry of Transportation and Communications as stipulated in the Highway Traffic Act of Ontario. Thus, prior consultation with and approval from this agency would be important to avoid future problems.

The study assessed costs based on three selected transportation methods – truck exclusively, and combinations of truck and rail, and truck and inland waterway vessel.

Because no specific destinations were considered, certain assumptions had to be incorporated into the calculations. For example, for the intermodal options, there had to be assumptions made about the road distance to and from the rail line and about access to docking facilities. Appendix H outlines the complete set of assumptions applied. It should be noted that Task Force members feel that the estimates are based on conservative assumptions.

The comparative analysis of the transport methods considered capacity, number of trips, frequency of trips, flexibility for site location, availability of transportation units, steam cleaning costs, transportation costs, infrastructure requirements, control and safety, probability of accidents and the public's perceptions of risk.

The distances to be travelled were set arbitrarily. For the truck option they were 50, 100, 200, 500 and 1000 kilometres. Because of water level limitations in the Great Lakes/Seaway system, only one quotation for a distance of 1100 kilometres from the origin was requested. This equates to a distance of 550 kilometres by rail, given that the waterway follows a more indirect route. Rail costs were initially calculated for distances of 250, 500, 700 and 1200 kilometres. The rail costs per kilometre were then calculated to allow for comparison of rail and truck costs for the same distances.

The results of the transportation cost analysis are summarized in Table 6.

Table 6

Comparison of transportation methods

Factor	Waterway/truck	Rail/truck	Truck
a **Cost ($million)**			
50 km	not applicable	not applicable	$7M
100 km	"	"	$12M
200 km	"	$20M (est.)	$20M
500 km	"	$34M	$48M
1000 km	$36M	$55M (est.)	$76M
b **Number of units**	1 vessel 100 trucks	2 trains 100 trucks	100-270 trucks (dependent on distance)
c **Number of trips**	70 waterway 44,000 trucks at origin and destination	410 trains 44,000 trucks at origin and destination	44,000
d **Timeframe** (dependent on distance)	2-3 years	3-4 years	1-5 years

Although the inland waterway/truck mode is the least flexible in terms of site access, the average vessel has a relatively large cargo capacity. Therefore, only 70 vessel trips would be required to move the radioactive waste to any given destination in the Ontario Great Lakes region. Costs were based on one vessel taking 5 days to reach the destination, making 3 return trips per month and taking 2 to 3 years to transport the total 880,000 cubic metres. The transportation cost of this intermodal method would be $36 million. While the usual regulatory bodies would enforce the regulations to ensure the safe movement of the waste material, the public may perceive the risk to be high for this method. Such a perception could relate to the visibility of a loose stockpile at the dockyard or be due to the need to move the waste material to the docking facilities by truck. Similarly, risks associated with the unloading operations and transfer of the wastes onto trucks dockside at destination would also likely be perceived as being fairly high.

For a disposal site located over 200 kilometres from Port Hope (the medium-to-long haul), the combined rail/truck method appears to be the most practical. While not quite as economical as the waterway option, the rail/truck alternative would offer more flexibility in site and route selection. A total of 410 train trips would be required. Two trains, making two return trips per week, would move all the material in 3 to 4 years. Transportation costs range from $20 million for a site 200 kilometres away, to $55 million for a site 1000 kilometres away. The regulations administered and enforced by the Canadian Transport Commission adequately provide for the necessary control over the movement of the low-level radioactive wastes. The study is based on the assumption that the public would perceive the risk to be lower using this method as compared to water transport. However, if the waste material had to be transferred to trucks from rail at the destination, there would likely be an adverse effect on how the public would perceive the risks.

The road mode allows the most flexibility for site location. However, this mode would entail 44,000 truck trips over a period of up to 5 years, depending on the final site location. Between 100 and 270 trucks would be needed, each making one or more trips daily. For this mode, a level of control and safety comparable to other modes would be more difficult to achieve. The costs to move the material to sites located from 50 to 1000 kilometres away were calculated. Estimates ranged from $7 million to $76 million. This mode would be the most economical to move wastes if the disposal site were to be located within 200 kilometres of Port Hope. The public likely would perceive the risk as being greatest with the truck option because of the high visibility of trucks carrying the material, their proximity to other traffic and the public en route, and the frequency of truck trips.

Other related costs

There are additional costs (outlined in Appendix H) associated with the waste removal for which the Task Force had only very rough estimates. These factors include waste digging costs, site rehabilitation once the waste is removed, steam cleaning of

the transport vehicles or units, infrastructure costs at origin and destination, and loading charges. They are summarized in Table 7 along with the ranges of transportation and facility costs.

Costs given in the studies do not include the costs of impact management and process administration. It must be stressed that while this exercise has not involved a highly refined costing methodology for some components, the Task Force members are satisfied that the key items – the facility and transportation costs – have been carefully estimated using the Port Hope area waste volumes as an example. Therefore, members are confident that the total project cost estimates as presented can serve as an appropriate guideline for estimating required resources to carry out the work on such a scale.

Other cost-related matters

The special nature of the project in the example gives rise to other noteworthy cost-related issues. First, the cost estimates of the different technology options are based on factors which, generally, are considered out of the ordinary for most capital projects. As a rule, waste disposal facilities have a 20- to 30-year operating life over which the capital costs can be amortized and off-set by revenues received from facility users.

Table 7

Summary of project costs

(assuming a waste volume of 880,000 m^3)

		($ million)
1	Transportation	7.0 - 76.0
2	Steam cleaning	0.02
3	Waste digging	17.6
4	Rehabilitation	5.0
5	Infrastructure	4.4 - 21.4
6	Property rental	0.1
7	Loading	1.0
8	Transfer station	0.2
9	Facility	216 - 540
	Sub-total	251.3 - 661.3
	Contingency 15%	37.7 - 99.2
	Total	**289.0 - 760.5**

In the case of the example scenario, however, from the start of operations there would be a volume of 880,000 cubic metres to be disposed of immediately. As is shown by the results of the transportation study, based on the logistics involved, "immediate removal" would imply a period of 1 to 5 years, depending on the ultimate site location and the transportation method selected. Even if it was assumed that the waste relocation would take the full 5 years, this would be nonetheless a very short time frame over which to write off the majority of the capital costs.

The second unusual aspect of this particular project (i.e., the example using the Port Hope area waste) is the fact that no waste management fees likely would be charged for the disposal of the historic wastes for which the federal government has assumed responsibility. These constitute a total volume of approximately 220,000 cubic metres, or 25 percent of the hypothetical 880,000 cubic metres total waste to be handled in the facility. Clearly, this too would compound the adverse effect on the break-even point for project financing.

4.7 Conclusions and recommendations

For the most part, the challenge in effective radioactive waste management lies not so much in resolving technical concerns, as it does in countering public apprehension about radioactivity and the effectiveness of current approaches to the regulation and management of radioactive waste disposal and storage facilities. While more difficult to address and evaluate, the resolution of non-technical concerns is essential to the success of any waste management initiative. Designs for responsible waste management plans must address these concerns and be relevant to the needs of the people involved.

Several technical options, suitable for the Ontario environment, are available for the management of low-level radioactive waste. Some are geologically dependent in that they incorporate natural barriers to contain the wastes, while others are not (i.e., they involve various types of engineered barriers which can be designed, constructed, tested and adjusted to suit the specific characteristics of the wastes they are meant to contain).

Therefore, we recommend that the full range of technical options for low-level radioactive waste management be kept open for consideration in the facility siting process and that the opportunity be given to potential candidate communities to select the design options which they prefer.

Notwithstanding the technical options considered, there is a need to exercise caution in applying the conclusions of mathematical models and risk assessment studies which attempt to establish the relative integrity and longevity of waste management technologies. Recognizing that such models and studies

inevitably involve assumptions which derive from extrapolations of limited data sets and that there is, therefore, potential for these assumptions to be erroneous, it is important to ensure that proper contingency measures are incorporated into any management plan for low-level radioactive wastes.

It is in this regard that the current approach to low-level radioactive waste management tends to engender public controversy. The Atomic Energy Control Board's regulatory document R-104 promotes the concept of "disposal" and lack of reliance on ongoing institutional controls. This approach is clearly not favoured by members of the general public who are justifiably skeptical of the seemingly "out of sight, out of mind approach" to waste management. Improvements in waste management technologies will undoubtedly occur and it is important that waste management plans be flexible enough to accommodate these improvements as they occur.

Therefore, we recommend that the concepts of "improved management" and "long-term storage" guide the development of any low-level radioactive waste management options.

Based on the responses of federal and provincial agencies with responsibility for ensuring the safe management of low-level radioactive wastes, there does not appear to be any serious current threat to human health or the environment from existing low-level radioactive waste accumulations in Ontario. It is indisputable, however, that in several cases, the longer-term security of present waste management arrangements is at risk and action to improve the management of these wastes is necessary. Improved in situ management may be a practical option for some of the existing wastes. A new facility will undoubtedly be required, if only to handle the Port Granby waste.

To determine what kinds of improvements are warranted, we recommend that each site where a waste accumulation is currently located be assessed to determine any site-specific requirements and constraints. Further, we recommend that in each case the local community be consulted to determine its concerns and waste management preferences.

In conjunction with actions taken to improve the management of existing waste accumulations, we recommend that the Atomic Energy Control Board provide the communities involved with a definitive statement certifying that the management activity undertaken is effective, and that it ensures adequate protection of the residents.

Such site assessments will assist in defining the required scale of the facility which in turn will enable realistic costs to be established for the low-level radioactive management facility.

The regulations and authorities governing the transportation of low-level radioactive wastes are distributed among several government agencies at both the federal and provincial levels. Together, these governments have succeeded in standardizing regulatory requirements and administrative practices.

There is another issue that arises from the responses received from the federal agencies and which warrants comment. Specifically, the Task Force found it disconcerting that the federal department with the mandate for health protection and for acting as medical advisor to the Atomic Energy Control Board, did not provide an opinion or information pertaining to any potential health risks associated with the low-level radioactive waste accumulations identified in the Inventory. Certainly it would be expected by the public that this department would be playing a more substantial role in gathering and making available such information. From the public's perspective, the Atomic Energy Control Board appears to be relying on its own resources for this kind of assessment, a situation that could be viewed with circumspection.

Therefore, we recommend that advisory agencies be assigned a more prominent and proactive role in establishing what are acceptable approaches to low-level radioactive waste management.

If the federal government is to remain responsible for the safe management of low-level radioactive wastes, it is only prudent and indeed incumbent upon the agencies involved to maintain adequate technical capability to ensure that sufficient and current information is available.

Regardless of the transportation method employed for any waste movement, appropriate radiation protection and monitoring programs are required by the Board to assure the protection of workers and the public. Given the socio-politically sensitive nature of hazardous waste management, the details of these regulatory requirements must be made public if unnecessary conflict in the facility siting process is to be avoided.

Therefore, we recommend that the Atomic Energy Control Board undertake public information programs as part of the siting process to ensure that regulatory requirements, their rationales and their impact on the siting of facilities are clearly understood.

Chapter five
Facility siting

5.1 Siting conflicts

Facility siting has become a highly contentious, conflict-ridden process. Nowhere is this more evident than in cases of siting facilities for hazardous wastes – especially radioactive wastes. People generally agree with the need to establish new and better waste management facilities. However, when a specific location for a proposed facility is announced, the announcement invariably is met by intense local opposition.

The problem is pervasive. All kinds of facilities publicly regarded as needed or desired – power plants, transmission lines, refineries, dams, hospitals, prisons, group homes – are met by strong resistance from local citizens. The problem is so prevalent it has earned its own label – the "not-in-my-backyard" or NIMBY syndrome. While there is no denying that NIMBY is a factor in siting disputes (there are those who simply do not want such facilities in their area), the acronym masks the complexity and legitimacy of the issues involved in the siting process. These issues must be fully understood if the process of facility siting is ever to become less confrontational.

The problem that lies at the heart of facility siting disputes is not related fundamentally to scientific or technological concerns. Even with perfect technical solutions, there still would be great difficulty in gaining local acceptance because the problem centres on the method and process of site selection. There are a number of reasons why current approaches to facility siting inevitably result in conflict and confrontation.

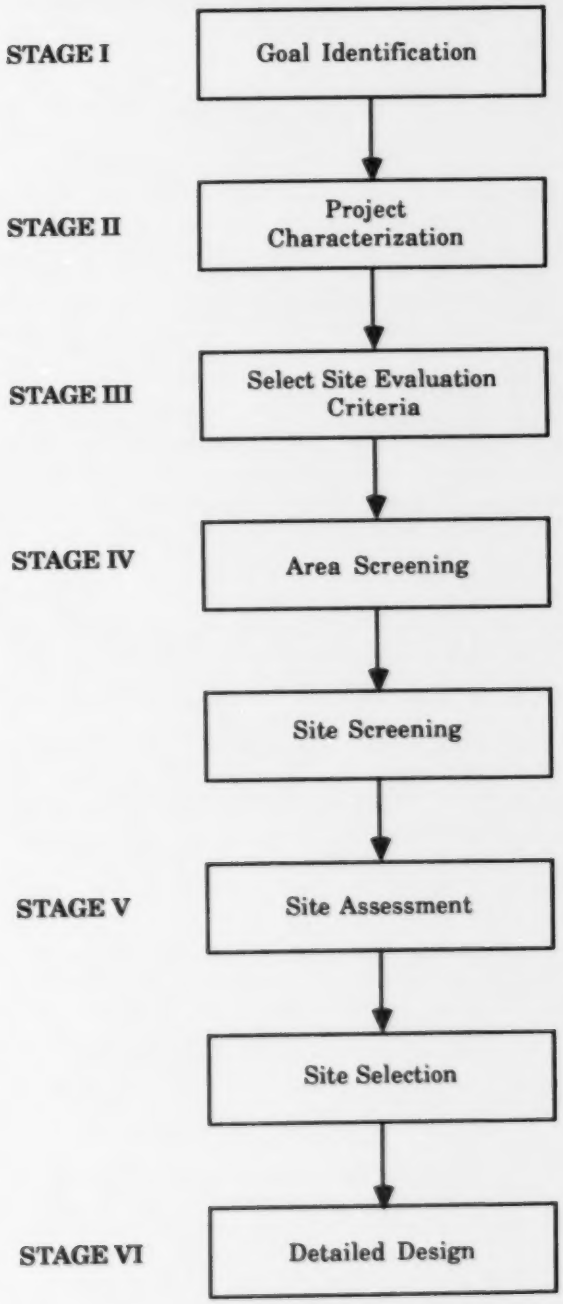
5.2 Current approaches to facility siting

For the most part, past and present processes of facility siting have adhered to a fairly straightforward method of site selection that involves "a progressive narrowing of scope from a very broad geographic area and range of factors to a short list of discrete sites and highly specific evaluation criteria."[13] This process uses a logical sequence of activities comprising six stages, as shown in Figure 14:

- ***goal identification***: requires a thorough assessment of the need for the facility and the overall objectives and requirements that have to be met;
- ***project characterization***: involves the identification of potential technology options and calls for a description of the physical/technical characteristics of each;
- ***selection of site evaluation criteria***: requires the specification and ranking of factors and indicators that will be used as a basis for comparison and selection among siting options;
- ***area and site screening***: involves the elimination of optional locations, using constraint criteria, to arrive at a set of potentially suitable sites;
- ***site assessment and selection***: requires a thorough comparative analysis of candidate sites so that these can be ranked and an overall "best" option selected; and
- ***detailed design***: involves in-depth environmental studies to identify the specific engineering and mitigation measures required to deal with the proposed facility's potential impacts.

Figure 14

Traditional facility siting process



The most significant feature of this process is its technical rationality. Its primary aim is to find the "optimum" solution, the one that represents the best match of ends and means. To achieve this, three implicit premises are adhered to in the study process:

1 Scientific and technical criteria should be the basis for assessing the merits of siting options. Accordingly, the process is rooted in the traditional notion that so-called "hard" data, objectively derived and empirically tested, are the only basis for sound decisions. Rigorous technical analysis, the systematic application of scientific method and the quantitative assessment of costs and benefits are emphasized as the means of evaluating optional locations.

2 Environmental factors, and not socio-political ones, should be the key determinants of site selection. More precisely, it is the technology/environment relationship that is the central concern in the facility siting process. This relationship is looked at in two ways. First, the technological option will have certain environmental requirements that have to be met (e.g., a certain acreage of land with suitable slope and stability). Second, the environment must be protected from any potential adverse effects of the technology (e.g., groundwater recharge areas and wildlife habitats or migratory stop-over points should be avoided). In site selection, the assumption is that these two concerns are paramount and must be met before any others. Accordingly, sites are eliminated or selected on the basis of the extent to which they satisfy the technology/environment relationship requirements. Then, and only then, does it become legitimate to address socio-political concerns.

3 The public's role in the process is secondary to that of the expert. Critical judgements determining the outcome of the process – the identification of technological options, the selection of evaluating criteria, the analysis of consequences and trade-offs, the ranking of alternatives, and the assessment of which is preferred – are generally made by the experts in isolation from potentially affected citizens. Public consultation, when it occurs, tends to be mainly to inform citizens of the issues being addressed and the methods being used, and to obtain their reaction. While this approach allows citizens to play an important role in keeping the technical analysis on track, their role is, nonetheless, a subservient one in the traditional siting process.

According to conventional wisdom, such technical rationality is better than other approaches to decision-making because it leads to recommendations that are objectively sound and ultimately in the interests of the "common good." In the context of facility siting, it has been presumed that such rationality, with its force of scientific fact, will legitimize siting decisions. This conventional wisdom is now being challenged from a number of directions.

First, the presumed objectivity of technical analyses is now held suspect by those who recognize that many of the technical decisions made in facility siting processes contain assumptions that come solely from the subjective judgements of the experts involved. Second, the concerns most relevant to the people who potentially will be affected cannot be taken into account until candidate sites are selected. By that time, those people rightly question the validity of the factors considered by experts when choices were made among siting options. Third, both the criteria which experts use to judge which option is "best," and the kinds of trade-offs they are willing to make, often are not in agreement with those that the community would prefer. Finally, and perhaps most importantly, the top-down nature of the technically oriented approach leads inevitably to one outcome – the imposition of a decision. It is this imposition and its "decide, announce, defend" orientation that fosters community resistance. Since residents are not involved in, or in control of, the early stages of the process when site elimination and selection criteria are developed, they come to resent what they see as the imposition of an unwanted facility. They feel that they are victims of technocratic decision-making.[14,15]

Such problems cast great doubt on the efficacy of a technically oriented approach to site selection. The process, because of its limitations, warrants reorientation to de-emphasize the paramount role it gives to technical considerations. This conclusion is further supported by evidence and criticisms reviewed by the Task Force concerning the way in which non-technical or "soft" concerns and issues tend to be addressed in traditional siting processes.

5.3 The "soft" issues

Fuelling local resistance to the conventional siting approach is the public's perception that social issues are not adequately taken into account. Methods of site selection have evolved over the past twenty years from rather crude site screening techniques to very systematic and highly technical procedures. Despite such advances, siting methodologies are weak in one crucial dimension – they often fail to respond to fundamental social concerns. Study after study shows that community resistance to siting proposals is linked to five key concerns of potentially affected residents: perceived risks; inequities in the distribution of costs and benefits; the stigma of an unwanted facility; a feeling of loss of control over forces affecting the quality of one's life and community; and lack of trust in proponents and regulators.[16,17,18,19] For various reasons, these and other "soft" issues are often dealt with ineffectively.

Perceived risks

Risk is a product of the anticipated consequence of an activity and the probability of its occurrence. Overall perceptions of risk, however, differ substantially between experts and non-experts.[20,21,22] While both see risk as a combination of probability and consequence, they use different criteria and weighting factors to arrive at an overall determination of riskiness.

The general public determines or perceives risks more by anticipated or feared consequences than by their probability. This process is similar to the one used when people buy lottery tickets – they concentrate on the prize and conveniently ignore the long odds against winning it. In contrast, professional studies focus more on probabilities. Thus, in a particular situation where the probability of death is one in a billion, the expert can perceive the risk of death as negligible, while a non-expert perceives the same risk as very serious precisely because the consequence, namely death, is serious. Experts tend to measure consequences in terms of expected losses measured quantitatively (e.g., annual deaths, dollars lost or lost days of work) and to assume that the willingness to accept risk is a matter of the trade-offs between expected losses and expected benefits. Non-experts, on the other hand, use expected death as only one criterion among many to judge potential consequences. They will also assign importance to other attributes of the risk situation such as: how voluntary the situation is; its catastrophic potential; how equitable it is; and its familiarity. Moral imperatives (i.e., the rightness or wrongness of accepting the risk) will also enter into the equation.

Extensive experience attests to the discrepancy between lay and expert perceptions on a wide range of risks. Quite apart from their differing assessments of the same risk, the non-expert and the expert may also differ profoundly on the question of which risks are worthy of consideration. For example, the medical expert will wish to concentrate on risks that are

capable of causing illness or killing people, but non-experts may give priority to risks that annoy or frighten them. Furthermore, people who are experts in one field may become non-experts when unfamiliar risks are under consideration; their evaluations move to concentrate on consequence. In other words, the expert approach tends not to carry over. This fact may explain how the perception that a serious threat exists from low-level radiation is so widespread, even among those with scientific training in other fields.

The risks posed by ionizing radiation to human health and well-being and to the environment have been better and more extensively studied over a long period than those of any other toxic agent including PCB's, dioxins and DDT. Naturally, these risk estimates contain a degree of uncertainty. Consequently, there is room for scepticism about the experimental observations and the scientific theories on which they are based. This scepticism accounts, in part, for the anxiety which the notion of ionizing radiation evokes.

As well, as mentioned earlier, there are certain characteristics of risks such as how voluntary they are, their catastrophic potential, their familiarity and their equity, that are known to cause either an overestimate of the probability of negative effects, or an exaggerated fear of consequences, or both. Ionizing radiation is well endowed with such characteristics. The fact that radiation is invisible and otherwise imperceptible to human senses makes its threat unfamiliar, insidious and even unfair.

There have been extensive educational efforts and numerous popularizations of the subject that have resulted in the publication of excellent material explaining radiation in everyday language with popular examples. (See Appendix J.) It seems clear, however, that further major educational efforts, whether made to the general population or to groups specifically threatened by radiation risks, will not necessarily alter existing negative perceptions.

The "exaggerated" perception of risks and danger is a fact of life when dealing with radiation, including low-level radioactive waste. Such perceptions are not always easily dispelled simply by providing the most impeccable probability data, any more than the buyers of lottery tickets are deterred simply by having the long odds against winning pointed out to them. This is not to say that all attempts at education are futile, or that the probability studies should be anything other than impeccable.

Gaining public acceptance of policy on low-level radioactive waste management requires continued effort to ensure that ionizing radiation and its risk are well understood. At the same time, an educational effort aimed at the scientific community and those involved in the development of public policy must be launched to ensure that the public's concerns are equally well understood and fully appreciated.

Complicating the problem of public perceptions of the level of risk associated with radioactive wastes is the confusion induced by two fundamental principles of radio-biological and radiation protection theory. The first is the "no threshold" hypothesis, and the second is the "as low as reasonably achievable," or ALARA, principle.

The first principle holds that there is no threshold below which exposure to radiation is entirely safe. The "no threshold" hypothesis – that any exposure to ionizing radiation, no matter how small, will increase the probability of a harmful consequence to an exposed individual – is an important scientific concept. It is equally important to note, however, both that the hypothesis cannot be proven and that the effects of low radiation doses are presumed (by extrapolation from the measured effects of relatively high radiation doses) rather than directly measured. At low radiation exposures, which in this context include exposures above those encountered in common medical diagnostic procedures, any harmful effects produced are lost in the overwhelming "statistical noise" of the much more numerous but indistinguishable effects that arise spontaneously. Notwithstanding this, it is generally agreed that it is wise to err on the side of safety and work from the assumption that there is no safe level.

The problem is that the "no threshold hypothesis" tends to over-sensitize the public to the hazards of radiation. Members of the public are likely to interpret the "no threshold" notion to mean that no level of radiation can be safe and therefore that none is acceptable. The notion of "no threshold" may also lead to the view that radiation, having no proven minimum safe level, is therefore uniquely harmful, far worse than the effects of other toxins. What this ignores, of course, is that everyone is constantly exposed to various levels of naturally occurring background radiation. In other words, some exposure is inevitable and is accepted.

The paradox for the public is that the no threshold concept seems to contradict this. Understandably, given this confusion, debate becomes quite heated in the context of a siting process, or in the consideration of proposals for management of low-level radioactive waste, when the issue of the standard of clean-up must be addressed.

This quandary is compounded by the second principle of radiation protection theory, namely the ALARA principle. It contains at least two potential traps, both involving differing interpretations of what is "reasonable." ALARA may be used in conjuction with the no threshold hypothesis to justify or insist upon a reduction in radiation exposure for its own sake, merely because it is achievable, even though the benefit that ensues cannot be measured. In other words, ALARA can sometimes lead to the radiological equivalent of obsessional handwashing beyond surgical standards.

At the other extreme, as endorsed by the International Commission on Radiological Protection, the ALARA principle acknowledges that social and economic factors must be taken into consideration when deciding what radiation exposure is "reasonably achievable."[23] This opens up the possibility that safety could be compromised as a result of considerations of cost and convenience. There are few agreed-upon guidelines for determining where the balance between these two extremes should lie. Understandably, the public has considerable difficulty in coming to a conclusion and in deciding whose judgement to trust, and under what circumstances.

In addition to the difficulties arising from the two principles, there is an AECB practice which adds further problems. The AECB has often declined to set common, detailed standards to be applied to all its licensees. Rather, it has allowed each applicant to make a specific proposal which the Board then accepts, rejects or modifies. Instead of applying common, well-understood and publicly justified standards, the Board develops, on an ad hoc basis, a series of individual licence terms and conditions. The intent is doubtless admirable, given that the aim is to avoid rigidity, to tailor requirements to individual circumstances, and to allow gradual and continual change to standards as new evidence comes in. Unfortunately, the Board inevitably establishes a "common law" as it goes along that does not have broad application and that creates the appearance of inconsistency.

The combination of the "no threshold" and ALARA principles, and the AECB practice causes a problem when attempting to determine clean-up criteria for low-level radioactive waste accumulations. Since the Board will not state how clean is clean enough, but prefers to ask those it regulates to propose a level based on the situation prevailing at each site, the public is left wondering what really is safe or, even worse, if safety has been traded off for cost savings. If by this process the AECB were to approve, for a heavily populated area, a site clean-up standard that was less stringent than one it had previously accepted for a site in an open field, the public might be left to question just who was being protected from what.

While calling attention to difficulties with ALARA and the Board's practices, it also must be pointed out that both could be said to be entirely in keeping with the Task Force's philosophy. The Task Force urges that the public, both generally and in specific clean-up sites or potential sites for a waste respository, be consulted concerning what options would be acceptable after having taken into account a variety of social and economic considerations. At the same time, members declare that there must be no trade off of safety. Under these circumstances, the members strongly suggest that the Board state "up-front" the minimum safety standards that it is prepared to accept as providing the necessary protection for human health and the environment.

Inequity and stigma

Local concerns about risks are matched by local concerns about perceived inequities and stigma. In the siting activity, a selected community is being asked to bear the burden of the facility's impacts and risks on behalf of the broader public. This community has to accept the disruptions caused by the facility as well as the possibility that people may regard the community as a less desirable place to live. Further, people living or working close to the facility are asked to alter their lifestyle expectations and enjoyment of their property to satisfy the needs of the larger community.

Such costs to the community not only are hard to determine, they are not usually offset by the benefits of the facility that accrue to the broader public. As well, when attempts are made to address these costs, they are frequently met by what might be called the "compensation paradox." In this paradox, those concerned with the plight of a community readily agree that something must be done by

the proponent to balance the inequity and stigma suffered by the few for the many. However, when a reasonable effort is made to provide compensation to the community (above what might appropriately be called mitigation for directly sustained damages), then the facility proponent is accused by those groups of attempting to bribe the community. Affected residents, however, generally hold another view. They feel they should be fully compensated and rewarded for taking on a facility that others are not prepared to accept in their community.

Loss of control

Given the dynamics of the "decide, announce, and defend" approach to facility siting, local residents become acutely aware of their loss of control over the process. As a result, the siting process becomes intensely adversarial with proponents attempting to justify their siting decisions and residents being equally determined to prevent facilities from going ahead. Because of this conflict, the siting process is often exposed to intervention from the political system. Such intervention further removes the residents from decision-making and opens up the possibility late in the process of introducing other factors and values which often seem extraneous.

Lack of trust

While this discussion of "soft" issues has outlined the problems associated with the present methods of siting hazardous waste material, one very important problem that dominates any discussion about low-level radioactive waste management remains to be assessed: the generally distrustful attitude held by the public toward the nuclear energy industry.

The North American nuclear industry finds itself in a paradoxical situation. In part to establish its credibility, the industry must site and operate a waste management facility, but to do that, it must first establish its credibility. Delays in developing high- and low-level waste management facilities have left the public with the impression that the industry does not know how to handle such material. This impression compounds the problem and contributes to a general lack of public trust in the nuclear industry.

Of the five factors underlying community resistance to siting proposals, the Task Force members feel that two – inequity and loss of control – are pivotal. Perceived risks, stigma and distrust are bound to take on more prominence in a situation where people feel that not only are they being treated inequitably but also they have very little control over decisions which affect the quality of their lives. If a greater effort is made to address potential inequities and the need for community control in the design and operation of the siting process, then the other three factors are likely to be much easier to handle.

This suggests that, at least in the case of low-level radioactive waste management, the siting process must address "soft" issues relevant not just to potential candidate communities, but also to communities where the wastes now exist.

5.4 Conclusions and recommendations

If facility siting is to become less confrontational and more co-operative, fundamental changes in the method and process of site selection are necessary.

Technical rationality, with its top-down orientation to decision-making, dominates the traditional siting process. It not only leads to the imposition of a decision on a community, but also inevitably results in a downplaying of the "soft issues" which lie at the heart of siting controversies. Perceived risks, inequities in the distribution of costs and benefits, the stigma of an unwanted facility, feelings of loss of control over forces affecting the quality of one's life and community, and lack of trust in proponents and regulators are all ineffectively dealt with at present by methods which emphasize rigorous technical analysis, scientific method, and quantitative measurements.

Both the "no threshold" hypothesis and the "ALARA" standard, now applied by the AECB and other regulatory agencies, play a significant role in making facility siting a confrontational process. Their application leads to public concern and confusion about the level of safety to be achieved. While recognizing a need for flexibility in devising waste management options, the Task Force concludes that clear assurance must be provided that safety will not be compromised.

Therefore, we recommend that the Atomic Energy Control Board establish up-front a set of explicit, detailed safety standards that can then be applied consistently to all its licensees.

Conflict and delay will be the inevitable result if standards and safety requirements are left as matters for debate in the siting process.

There is sufficient doubt about the efficacy of technical/rational site selection methods to warrant de-emphasizing their role in site identification. Greater reliance must be placed on methods which enable social considerations to be better factored into the decision-making process. In addition, the process needs to be reoriented away from technocratic decision-making towards collaborative problem-solving.

Accordingly, we recommend that there be consultation with the general public and with residents of specific communities where clean-up will be undertaken, or with residents of potential sites for a waste repository to get their views as to what options are acceptable, bearing in mind social and economic considerations.

Of all the factors accounting for community resistance to siting proposals, it is the inequity and feelings of loss of control, that result from the imposition of a decision, which appear to be of primary significance in creating conflict in facility siting processes. If these factors are effectively addressed, the others – perceived risks, stigma, and lack of trust – are likely to be more easily managed.

Chapter six
Regulatory issues

6.1 The Atomic Energy Control Board and its role

In reviewing low-level radioactive waste management in Canada, and more particularly the approach that was taken to Eldorado's proposed facility, the Task Force noted a series of problems, the solutions to which would seem to require changes in the regulatory philosophy and practices of the Atomic Energy Control Board.

When the Board became involved with the waste management issue in the Port Hope area, its staff members did not make their presence well known in the community. Although in recent years Board staff have made numerous efforts to communicate with concerned citizens, their visibility and that of Board members themselves at the community level is not as high as many would like it to be, or as it should be. The AECB has not involved the community widely in the management and monitoring of the various sites, even though there has been considerable interest expressed in such participation. Furthermore, information concerning local issues is not made readily available to local communities and their citizens. The AECB's lack of social awareness may be connected to the composition of the Board which does not have the broad range of expertise necessary to deal with all the relevant siting issues of the day (i.e., it is dominated by technical experts). This is almost inevitable, given the small size of the Board as currently constituted under the Atomic Energy Control Act. Furthermore, the Board must deal with the public perception that it is a protector of the nuclear industry. This perception is given further credence by such practices as the AECB's failure to apply sanctions when licence conditions are violated, as occurred at the Port Granby facility.

These problems are further exacerbated by the fact that the Board only became involved in the active regulation of waste management facilities late in the development of the nuclear industry. Many of the people with whom the Task Force spoke were not aware that the Board had *not* had a role in determining the choice of the low-level waste management site at Port Granby, or the one at Welcome. Further, people did not seem to appreciate the fact that the Board's first licence covering waste management practices was not issued until 1975 (for Port Granby), that this licence was followed up the next year with a directive for improved management practices, and that within another four years Eldorado was instructed to commence planning for a new site to dispose of the waste contained at Port Granby – a rather rapid sequence of events. Thus, many of the negligences over which people express concern actually occurred prior to regulatory controls. While the Board's performance on specific issues must therefore be judged only on actions taken over the last twelve years, the rationale for the non-involvement of the Board prior to that time is open to question.

6.2 Standards setting

As has been intimated in this report, the hazards of ionizing radiation are well appreciated, and have been for many years. Consequently, several national and international bodies, including the Atomic Energy Control Board, are working co-operatively to minimize the potential dangers. The basic radiation standards, which from time to time have been made more stringent, are recommended by the International Commission on Radiological Protection. These recommendations are used by all major countries as a basis for protection standards against the biological effects of ionizing radiation. The AECB has adopted them. It is important to note that the ICRP regards all increases of radiation as undesirable, and it has recommended that they should be kept "as low as reasonably achievable" – i.e., the ALARA principle. The recent recommendation of the ICRP, that the maximum permissible occupational radiation exposure for the general public be reduced from 5 to 1 millisieverts per year (and ten times this level for radiation workers), exemplifies the adherence to the principle. However, the extent to which this major revision of the standard will reduce health effects due to radiation is indeterminate.

The ICRP recommendations essentially are expressions of opinion based on deduction from scientific findings. However, because the ALARA principle (also endorsed by the ICRP) acknowledges that social and economic factors must be taken into consideration when deciding what radiation exposure is "reasonably achievable," the inclusion of social scientists in the organization would be a desirable step. Similarly, the regulatory boards and advisory panels of the AECB, currently dominated by physical scientists and engineers, would be strengthened by the inclusion of social scientists in their membership, particularly experts in risk assessment, and measurement of the public's perception of risk.

Input from the informed public can be particularly helpful when value judgements or social issues such as those relating to the management of low-level radioactive wastes are involved. With the inclusion of such judgements, the public gains assurances that all relevant issues have been considered and, as a consequence, that greater accountability in the decision-making process has been fostered.

Although there are no scientifically proven minimum safe limits for concentrations of certain toxic and carcinogenic chemicals in food, air, and water, such "safe limits" in fact have been set by the appropriate food and drug administrations or their equivalents. The implication is that a dose of low-level radiation with no acceptable safe level is more health-threatening than a low-level dose of, for example, dioxin. In fact, the Task Force finds it is more reasonable to accept a maximum permissible level for ionizing radiation because background radiation is a ubiquitous, naturally occurring phenomenon, whereas there is no naturally occurring level of polychlorinated biphenyls.

In light of the foregoing, it should be reiterated that it is essential that the AECB declare, following public consultations, detailed minimum standards that it is prepared to accept. Furthermore, information should be published which states unequivocally the degree of threat to human health and the environment posed by the several radioactive and toxic non-radioactive contaminated deposits in the Port Hope area and in other waste accumulations.

6.3 Conclusions and recommendation

The AECB obviously must play a lead role in setting the specific standards that will guide efforts to improve low-level radioactive waste management practices. Consultation with potentially affected publics will be essential if these standards are to be understood and accepted as valid.

There has been failure to establish realistic safety standards in the management of radioactive waste sites that take into account the natural ranges of background radiation.

There is failure on the part of the regulators to communicate adequately with the residents of communities directly affected by licensing decisions made.

There is too rigid adherence to concepts and philosophies (such as the permanent disposal concept, which AECB endorses) which do not take public opinion into account.

The AECB, and its advisory committees and panels, are dominated by physical scientists and engineers. The point of view and philosophies of social scientists are not, by and large, taken into account.

Accordingly, we recommend that there be a fundamental change in the practices of the AECB regarding the management of low-level radioactive wastes.

A co-operative siting process

The remainder of this Report presents the Task Force's suggested solution to the facility siting problem. What is proposed is a five-phase process (the Process) that is based upon the principle of co-operation and assures full consideration of the needs and views of all the stakeholders. In Chapter seven, the key factors that must be involved in this Process – the basic principles, the essential safeguards, and the potential impacts – are described in detail. In the final chapter, the Process itself and the steps to be followed in its implementation are presented phase-by-phase. The chapter concludes by specifying a number of preliminary measures which must be undertaken prior to initiation of the Process, if the Process is to be successful.

Chapter seven
Key features of the process

When the Task Force began work in January 1987, there was a strong consensus that the existing process of facility siting was fraught with problems and that changes were needed to make it less confrontational. It was not difficult to identify the nature of the problems. The challenge came in trying to determine what to do about them.

Throughout the Task Force consultations, members heard many thought-provoking suggestions from government officials, facility proponents, public interest groups, academics and concerned citizens on what was needed to improve the facility siting process. There was consensus that it was time for significant changes in siting principles and procedures. The Task Force's own analysis of the situation confirmed this. The five-phased siting process recommended here, while adhering to the requirements of the existing regulatory context that governs facility siting, represents a fundamental departure from current siting practice. It is essentially a non-adversarial approach to facility siting, one which from the beginning aims to involve communities in voluntary collaboration and joint problem-solving. Its principles, safeguards, and impact management strategy all reinforce this basic goal.

7.1 Principles

Drawing on available research into siting disputes, the input received by the Task Force from its consultations, and the experience of its members, the Task Force identified five principles that it feels must be followed if the process of siting a facility for low-level radioactive waste management is to be more co-operative and less conflict-ridden. Each principle and its underlying rationale are set out in the following sections, and a brief reference is made to the point(s) at which each is applied in the recommended Process.

1 **The community should volunteer, and have the right to opt out of the Process at any time, rather than be selected by the project sponsor at its discretion.**

As discussed in Chapter five, current approaches to facility siting inevitably result in the imposition of a decision on a community. This "selection" of a community, perhaps more than any other factor, accounts for much of the conflict that accompanies siting initiatives. Proponents are put in the position of having to justify site selection decisions and convince the community that these decisions are sound, an approach that is inherently confrontational.

The Task Force members accept from existing processes the need for detailed assessment of potential impacts and of site suitability relative to the proposed project options. Indeed, this requirement is built into the fourth phase of the Process. However, all other parts of the Process, especially the phases involving site identification, represent a fundamental reorientation of facility siting practices.

By adopting the principle that communities should volunteer, the premise that siting options should be chosen in the first instance on the basis of the extent to which they satisfy technological/environmental factors is rejected. The elaborate site-screening methods that are now used by proponents to narrow the site search down to a few candidate communities have been aptly described as a "punishing procedural marathon that goes nowhere."[15] Regardless of how well site assessments and comparative evaluations are carried out, it is questionable "whether they could ever be done well enough to promote a technical consensus on the fairness and soundness of the choices."[15]

However, certain constraints may have to be applied at the start of the Process to eliminate obviously unsuitable geographic areas from further consideration. The first phase of the Process involves the establishment of siting guidelines that set out, among other things, the characteristics of suitable sites. This activity is intended to aid in the identification of basic siting constraints. These siting guidelines also allow potential volunteer communities to assess for themselves whether they have, within their borders, areas that satisfy the criteria of a "suitable" site.

Beyond such preliminary screening, there is only one reason why communities may have to be picked out rather than being allowed to volunteer – and that is if no communities volunteer. It must be stressed that only in such a case would the current technical screening approach to site selection come into play as the fall-back position to the new Process with its volunteer principle.

To reiterate, the key to non-confrontational siting is to seek voluntary identification of potential sites by the communities themselves. The next three principles aim to reinforce and support this approach.

2 The community should be a partner in problem-solving and decision-making throughout the Process.

It is not enough to give any community the right to volunteer as a site for a proposed facility. Communities also must be able to exercise a strong degree of control in directing the siting process.

In this regard, the community should have an equal say, along with technical experts, in determining the kinds of studies that should be carried out and the factors that should be considered. Equally, any information developed to aid problem-solving and decision-making must address the community's concerns, issues and desire to know.

As noted previously, one of the factors that accounts for the strong negative reaction that so often accompanies siting proposals is the feeling of loss of control over forces affecting one's quality of life and community. The traditional siting process effectively shuts out potentially affected publics on the premise that siting is the domain of technical experts and qualified professionals. The Process rejects this premise because it usurps the public's rightful role in the many judgemental aspects of facility siting – those instances where choices have to be made regarding the alternatives to assess, the variables to consider, the weight to give to these and the trade-offs to be made. Furthermore, the premise reinforces an "us-them" relationship between experts and residents and, in so doing, inhibits the two-way flow of communication that is essential to the development of mutually acceptable siting solutions.

3 The community should receive compensation to offset unmitigable impacts and to enhance local benefits.

Facility siting invariably involves inequities in the distribution of costs and benefits. Generally, benefits are widely dispersed while costs tend to be localized. Compensation of the community for any burden it must bear on behalf of the broader public interest is essential to a fair and equitable siting process.

Although the issue of inequity is well recognized, current impact management strategies tend to side-step the issue. The emphasis has been on expanding the range of mitigation measures (i.e., measures taken to prevent or minimize potential impacts) that are applied. The assumption appears to be that expending more effort and money on impact mitigation somehow negates the need to address the imbalance of costs and benefits that inevitably accompanies siting decisions.

The Task Force does not accept this. Compensation must not be equated with mitigation. Even with the best of mitigation, there will still be impacts that cannot be avoided or reduced to acceptable levels. It is both reasonable and fair to require that any hardships or difficulties that a community might experience as a result of siting should be compensated, either directly or indirectly, using both financial and non-financial means.

Furthermore, compensation not only should be provided to offset unavoidable negative effects, but also should be used to ensure that communities gain a net benefit by accepting such facilities. In other words, the aim of compensation should be to ensure that by accepting the facility, the community is not just as well off as it was, but better off. For this reason, reward measures or incentives are regarded by the Task Force as an important aspect of any compensation package. In a process where a community is expected to volunteer to accept a waste facility, it is reasonable to assume that the community will want to enhance its general welfare by this action. Along with compensation measures that attempt to offset potentially negative impacts and maximize benefits to the community (from the positive features of any economic spinoffs that might occur), the volunteer community is also entitled to a reward.

There may be some concern that reward measures will impart an element of bribery to the siting process, thereby leaving it open to abuse. Task Force members recognize that this potential does exist, but are confident that the recommended siting process has sufficient safeguards against this. A bribe is anything that is promised or given as illicit payment and that induces a betrayal of trust. The "reward" that is proposed for incorporation in the Process as part of compensation is well-deserved. If it is an explicit component of the

impact management program, if the reward measures and limits are clearly and openly specified, if the potential risks and impacts are made known, and if at the same time safety standards are assured, as recommended, then there will be little potential for abuse.

4 **The community should have the right to select, from given technical options and impact management measures, the ones that are acceptable to it.**

What constitutes an "acceptable" technical option and an "appropriate" level of impact management are often key points of contention in current siting processes. At present, these are usually regarded as matters for experts to decide. Community preferences are seldom taken into account, especially if they involve additional impact management measures beyond those required to meet minimum levels of environmental protection or social service standards. Yet, it is the community which must live with the facility. If the community is to be comfortable with the facility, then the community's needs for assurance must be met.

The community should be able to choose for itself, from a range of technical impact management options, those measures that, for it, best address negative effects and enhance potential benefits. The last phase of the Process focusses on the negotiation with the volunteer communities of formal impact management agreements which detail the specific measures to be adopted.

5 **The Siting Task Force responsible for the implementation of the Process must ensure that the safety of the environment and human health are not compromised for any reason.**

The aim of this principle is to make facility siting less confrontational – but not at any cost. Clearly, when the facility is complete, it must be safe. It must be sited in a suitable area and designed to meet required levels of environmental protection. No one will be served if safety is compromised.

This principle is derived from the fundamental objective of the federal Environmental Assessment and Review Process (EARP), which is to promote greater protection of the environment by requiring thorough consideration of environmental factors, broadly defined, in all phases of decision-making. Environmental considerations are built into the Process from start to finish.

The first phase of the Process involves the development of siting guidelines that stipulate the characteristics of a suitable site. These will be referred to by the Siting Task Force and volunteer communities in assessing the acceptability of potential siting options, in terms of safety and environmental factors. The information and consultation sessions conducted in Phases two and three focus on ensuring that potentially interested communities are provided with a sound understanding of environmental and safety concerns. Similarly, throughout the fourth phase – Project Assessment – the Siting Task Force has the responsibility for determining whether any of the volunteered sites offered by volunteer communities should be withdrawn from the siting process because they do not offer technically sound options and hence are unacceptable for environmental and safety reasons. The final phase of the Process involves the development of impact management strategies to prevent or minimize any potential adverse environmental effects and to ensure ongoing environmental protection.

Taken together, these five principles represent a reorientation of the siting process away from confrontation toward co-operation. They give the local community an essential degree of control while, at the same time, ensuring that required standards of safety and environmental protection are not compromised.

The Process also recognizes that, in some circumstances, when a community volunteers itself as a candidate site for the proposed facility, a neighbouring community may also be affected and will want to have a part in the problem-solving and decision-making process. This could occur, for example, if the proposed site for the facility were to be situated near a municipal boundary. In this situation, all of the aforementioned principles would apply to both communities.

7.2 Safeguards

As demonstrated in the five principles, the basic assumption underlying the recommended Process of facility siting is that as long as safety has been ascertained, community concerns should be on par with technical factors. The Process ensures that the local officials and the public have a key role in deciding what constitutes an acceptable facility and how impacts ought to be managed.

However, it is also recognized that, unless there are safeguards, a facility siting process that aims for the voluntary participation of local communities could be labelled as "locational opportunism" in that it might be seen as attempting to exploit economically disadvantaged communities. To guard against this, the Process incorporates five features:

1 **An explicit, up-front impact management policy will be used to ensure that all communities are aware of the range of options available to them.**

One fundamental objective of the recommended siting process is that the facility will provide a net benefit to whichever community accepts it. Given this objective, it is reasonable to expect that communities will compete for the proposed facility. The concern, therefore, is to ensure that this competition is fair.

The net benefit that might accrue to any one community is a function of the specific kinds of impacts likely to occur, given the chosen technology and site, and the specific kinds of impact management measures adopted to deal with these. Each community will have to devise an impact management strategy to suit its own particular circumstances, needs and preferences. It is this activity that will form the basis of competition among communities. Each community may develop a different impact management proposal. To ensure that this competition is fair, all communities must be fully informed of the range of impact management options available to them so that they will not unknowingly neglect to include a beneficial impact management option in their proposal.

The first phase of the Process focusses, in part, on the development of impact management guidelines to assist volunteer communities in developing an appropriate strategy for dealing with potential impacts. Impact management is discussed in more detail and a number of potential options are outlined in section 7.3 of this report.

2 **Community-hired advisors will be employed to ensure that local interests are protected in the process of joint fact-finding and problem-solving.**

Phase four of the Process is designed to ensure that communities share with the Siting Task Force all siting and impact management decisions. Of course, the capabilities of communities to exercise this control effectively are likely to vary considerably. Small municipalities with limited staff, resources, and/or experience in facility siting processes are most likely to be at a disadvantage compared to other larger and/or more experienced communities. Therefore, it will be necessary to ensure that all communities are provided with the expertise they need to safeguard their own interests, both during the siting process and afterwards.

3 **Thorough site and technology assessments, designed jointly by the community, the Siting Task Force, and technical experts will be carried out to ensure that decisions are based on full information.**

A process such as the one recommended, that aims for voluntary acceptance of a facility, must adhere to the principle of "informed consent." Decisions made by volunteer communities must be based on full information. Potential implications of the facility, both positive and negative, must be known to communities before they make any final decision about allowing themselves to be recommended to Cabinet as volunteers. Phase Four of the Process involves detailed environmental, social, technical and economic assessments. These studies, along with the AECB's safety analyses and the comments of other regulatory agencies, will be circulated for full public review and discussion as they become available. Public discussion sessions will be organized as required to provide opportunities for the community and any interested groups and individuals to raise concerns or issues they feel need further study so that these can be resolved.

4 **A broadly-based Community Liaison Group will be established to work with the Siting Task Force and local officials.**

The primary objective of the Process is to gain "community" acceptance of the siting proposal. While it is the municipal council that is the decision-maker of record in the Process, it is necessary to ensure that the council's decisions reflect not only its corporate interests but also the interests of the community at large.

In the early phases of the Process, the Siting Task Force will deal mainly with municipal councils. However, from the third phase on, consultation efforts will involve the broader community. To ensure that residents' concerns will be brought forward and that decisions made in the Process will be representative of the broad community, it

is recommended that a community liaison group be set up. The members, their respective terms of office, reporting relationships, decision-making powers and expected results will be established by the Siting Task Force in negotiations with the municipal council. The Community Liaison Group, although independent, will be accountable both to municipal council and the Siting Task Force. This Group will receive its funding and technical resources through the Siting Task Force.

It is important in the Process to gain an accurate assessment of the breadth and depth of public opinion in a particular community regarding radioactive waste and specific siting concerns. This is essential because issues concerning radiation often provoke strong feelings that work to magnify perceived risks. There is a danger that activists may create the impression of either widespread opposition to or acceptance of a nuclear issue in an affected community when, in fact, this perception may be at odds with the opinion of the majority. Because of this pitfall, decisions in traditional siting processes often respond to the vocal minority, while the views of the "silent majority" often are not known. The use of a broadly-based Community Liaison Group in the Process provides the means of dealing with this potential problem by ensuring that there is a balance in the views represented. This safeguard is further reinforced through the use of public opinion polls to measure community acceptance of any community's proposal.

5 **Funding will be provided to allow for community participation in the Process.**

It follows from the previous safeguard that full community participation is essential in the Process. Accordingly, funding must be provided to ensure that everyone who wishes to be involved in the Process can be. In the Process, the Community Liaison Group is charged with the responsibility for advising the Siting Task Force regarding whom to fund, as well as how much funding to provide to each applicant. Resources are to be made available through the Siting Task Force for such activities as secretarial support, photocopying, mailing, research and telephone calls. However, given the joint problem-solving and non-adversarial orientation of the Process, funds are not to be provided to cover such things as legal fees or counter studies.

7.3 Impact management

The overall goal of any hazardous waste facility siting process must be to protect human health, the environment and the well-being of communities affected by the siting decision. In the case of low-level radioactive waste, this protection must extend not only to the community that accepts the required facility (the volunteer community), but also to the communities with existing waste accumulations and those situated along the major access routes. To achieve this requires sound, responsive management that prevents, minimizes or offsets negative impacts and enhances positive ones.

Types of impacts

The magnitude and types of impacts inherent in the siting and operation of a required facility vary depending on numerous items ranging from the characteristics of the wastes themselves to the characteristics of possible sites and the technical options that could be applied at those sites for waste management. This section of the report defines the two main classes of impacts and the six categories which comprise each class.

In fundamental terms, impacts are classed as either standard or special.[24,25] Standard impacts are those likely to be felt by communities undergoing any significant development activity. They relate to the normal resourcing and servicing demands that accompany the planning, construction and operation of the development, and the capability of communities to deal with such demands. How much impact will be felt, and which impacts are likely to be felt by communities, vary greatly depending on the size of communities, their resource base, the dependence of the project on local resources and other such items.

By contrast, special impacts are associated uniquely with facilities regarded as hazardous. In the case of low-level radioactive wastes, the special impacts derive from the fact that the transportation, disposal, storage and management activities involve radioactive materials. Along with standard impacts, the radioactive nature of the waste produces fear and apprehension which create special impacts to be managed. As examples of special impacts, there could be ongoing stress and resultant health problems, there could be stigma attached to a volunteer community, or there could be an out-migration of residents and a drop of property values, all from the siting of a facility. Each of these classes of impacts – standard and special – must be addressed in a sound and responsive manner by the siting process.

While the interplay of local variables relative to siting will produce unique impact management demands for any community involved in the Process, the range of both standard and special impacts can be listed under six primary categories: economic, demographic, housing, public services, fiscal, and social.[26]

Economic impacts: including both economic benefits (e.g., enhanced employment opportunities, provision of goods and services, related spinoffs), and negative economic impacts (e.g., the loss of economic growth potential, increased local costs of goods and services).

Demographic impacts: including such items as fluctuations in population growth, conflicts between community residents and facility workers, and changes in socio-cultural dimensions which affect the demographic characteristics of communities.

Housing impacts: including the supply, the cost, the availability and the value of housing in communities.

Public services impacts: including effects on water and sewer facilities, law enforcement, fire protection, social services, need for personnel, recreation facilities and programs, public administration, management and planning, emergency response programs and health services.

Fiscal impacts: including all those problems created by the difference in time between the demand for new services and other infrastructure improvements and the collection, accumulation and eventual expenditure of revenues to meet these demands.

Social impacts: including all the social implications of facility siting and operation such as increased community fear of negative health effects, changes in the social fabric and structure of communities, and the ''stigma'' effect and its influence on residents.

Many of the potential negative impacts involved in siting and managing a waste management facility can be avoided outright by careful site and technology selection, appropriate site design and the institution of effective operating practices. However, not all impacts can be avoided. Therefore, steps must be taken to minimize problems and offset unavoidable adverse effects. In addition, any difficulties or hardships that might be experienced by those affected must be dealt with equitably and quickly. Finally, an effective siting process must enhance potential local benefits, where applicable. The aim of an impact management program is to ensure that these objectives are achieved.

Impact management — the fundamentals

Reduced to its basic components, impact management involves four kinds of measures, as discussed in the following segments.

1 ***Mitigation measures*** prevent or reduce potentially negative effects as, for example, in stockpiling excavated soil well away from streams to prevent or minimize the potential for increased sedimentation and the destruction of fish spawning habitats. Similarly, building a berm or barrier around the site of construction operations is a measure that reduces the potential for off-site noise and negative visual impact.

2 ***Compensation measures*** offset unavoidable negative effects and enhance local benefits. For example, if it appears that property values may be negatively affected due to unavoidable increases in noise or other nuisance effects, then a property value protection policy that guarantees property owners fair market value for their property provides one means of offsetting such a negative impact. As well, potential local benefits can be reinforced through such measures as a facility hiring policy that gives preference to local residents and includes provisions for the training of unskilled workers. In addition, community well-being can be enhanced through reward measures such as contributions to libraries and funds for the development of recreation centres and other social service amenities.

3 ***Contingency measures*** aid in the detection and timely response to potential problems and unanticipated effects. Included in this category are such measures as monitoring, emergency response plans and remedial action programs.

4 ***Community relations measures*** ensure that effective two-way communication and joint problem solving mechanisms are in place to resolve concerns and issues on an ongoing basis. Examples of such measures include putting in place a complaints procedure, a claim-resolution process and other such measures that explicitly address the need to maintain positive relations between the facility operator and the community. Such measures are essential to the long-term durability of any impact management agreement.

There are many ways to apply such impact management measures so that the co-operative feature of the siting process is enhanced. The specific measures eventually implemented depend on the kinds of impacts that actually might occur. The following three sections outline the types of impacts which could occur in potential volunteer communities (where the facility would be developed and operated), communities with existing wastes (which will experience impacts as those wastes are removed) and communities located along access routes used by waste transport vehicles.

7.4 Potential impacts on a volunteer community

For the volunteer community, the magnitude of the six categories of impacts of the required facility vary depending on the characteristics of the technological option selected and the characteristics of the community itself. This section outlines the possible range of standard and special impacts in each of the impact categories to be managed. To offer the fullest view, the assumption is made that the volunteer community is relatively small and that the scale of the facility is significant (in terms of other ongoing construction projects).

Economic impacts

In terms of standard economic impacts, both employment opportunities and economic spinoffs usually are considered by local residents as major beneficial consequences of any new development. Construction activity and the day-to-day operation of the facility can provide job opportunities for unemployed residents. In addition, people may have the option of switching to a new higher-paying job and, as a result, family incomes may increase.

Such benefits, however, do not come without the possibility of negative impacts. New employment opportunities and higher wages can result in employees leaving existing jobs. There may be upward pressure on local prices for goods and services if supply does not keep pace with demand. Furthermore, purchases of supplies or materials for the facility may not be made in the area, thus limiting potential benefits for local business.

To determine the levels of standard economic impacts that are likely, impact studies must identify the match between the requirements of the project and the capabilities of the community. Where the local community can supply the necessary personnel, materials and services, there are direct benefits with some associated negative risks. Where the influx of new employees and their families creates a demand for housing that exceeds local supply, land values may increase or there may be an inflationary price trend. Local residents, particularly those with fixed incomes, could feel the adverse effect of this economic impact. Impact monitoring programs must be designed with such factors in mind and include management measures to minimize such negative effects.

In terms of special economic impacts, the acceptance of the low-level radioactive waste facility may influence several basic sectors of the economy apart from those related to the facility itself. For example, the volunteer community may lose out when being considered for new business ventures if owners are influenced negatively by the existence of the facility and locate their operations elsewhere. Accordingly, the economic growth potential of the community and the potential negative effects of attitudes about radioactive waste must be compared so that, where the project limits the community's future opportunities, suitable compensation arrangements can be made. Similarly, any impact management plan must attempt to maximize potential benefits. This can be accomplished during impact assessment studies by investigating spinoffs or economic activities associated with the technology, materials and personnel of the facility. This might also involve examining economic opportunities related to such research activities as studies of radioactive waste management or geophysical research.

There could also be negative economic impacts in the tourist industry in the community. For instance, visitors might stop patronizing local businesses because of the perceived risk associated with the facility.

Special economic effects may also extend to individuals in the community. For example, long-term residents may worry that having the facility in the community will result in a drop in property values. While research indicates that such an effect is generally minimal and short-term, the correct management response is to incorporate a property value protection program within the formal impact management agreement.

Demographic impacts

Standard demographic impacts resulting from the siting of the facility could be extensive in the volunteer community. The influx of workers during the construction and operation stages of facility development can substantially change the local demographic characteristics. The implications of such

change include: conflict between newcomers and existing residents whose cultural and social traditions may be at odds; stress on local services such as schools and hospitals; and alteration of the power structure of the community (a potential problem particularly if the new residents are generally better educated or better paid than the existing residents). New arrivals will likely have different training and, in all likelihood, different interests and lifestyles. These new arrivals may, therefore, change the socio-cultural nature of the community. Efforts must be made both to minimize conflicts (especially during any construction phase that employs work-week residents) and to ameliorate concerns about losing the level of familiarity among long-time residents.

Extensive special demographic impacts also exist because, unlike "normal" development projects, those which deal with radioactive materials may result in a decline in the local population. Surveys have shown that a large percentage (up to 53 percent) of respondents indicated that they would move away from a repository site in their area.[27] However, studies in the area adjacent to the Three Mile Island generating station following the release of radioactive steam from the power plant showed no significant increases in out-migration.[28,29] While such out-migration is unlikely in the siting of a low-level radioactive waste management facility, the possibility of this situation occurring must be considered in the development of impact management proposals.

Housing impacts

The number of new arrivals in the community will govern the standard housing impacts of the project. For example, a relatively sudden increase in demand may outstrip the ability of local builders to produce suitable accommodation, thus artificially inflating house prices. Therefore, to reduce the negative effects of the project on the housing supply and market, explicit attention must be given to the range of housing needs and the resources required to meet those needs without adversely affecting the existing situation. Temporary housing may be a solution.

Similarly, for special housing impacts, if the community's perception of facility risks results in a decline in the local population or fails to induce secondary population growth, property values may fall and there may be an increase in vacant housing.

Public services impacts

The entire service structure of the volunteer community, from sewers to medical services, can undergo significant standard impacts from the siting and operation of the new facility. Services provided to individuals may be strained as the new facility evolves, depending on the current services available and the number and characteristics of new arrivals. For example, pre-development populations may not have been large enough to support or require certain types or levels of services. However, with population increases resulting from the development of the facility, new services may be needed.

The ramifications of the new facility in each of these areas must be examined in the pre-development stage. Resources to deal with anticipated standard services impacts must be allocated and a monitoring program established. Furthermore, additional monetary payments or grants-in-kind must be available to cover unanticipated costs which emerge as the facility work force stabilizes.

To manage the special public services impacts which result from facility siting requires ongoing monitoring and emergency response programs to address the perceived potential danger associated with the facility. Further, funding for these programs must be supplied to the community; the community itself should play a key role in the design of monitoring programs and their reporting procedures. In addition, health services may have to be expanded to provide specialized equipment or training as necessary for monitoring and emergency response. Such requirements must be identified during the impact analysis stage of the Process and be documented in the development agreement.

Fiscal impacts

Standard fiscal impacts are particularly evident when a community is left to pay for increased public services demands (resulting from a facility siting) out of property revenues or taxes on related secondary development. Many of these impacts can be reduced or eliminated with effective impact management regimes.

Up-front payments for infrastructure improvements identified by initial impact studies reduce the need for capital expenditures. Further, the monitoring studies and recognition of the obligation to provide administrative assistance and financial support for public services for both new employees and pre-development residents reassures the volunteer community that fiscal impacts will be mitigated. Other management options include grants-in-lieu of taxes

or prepayments to the community at a rate that reflects the fiscal impact of the project. If a number of years' taxes are prepaid, the community receives the necessary capital to undertake needed improvements or to feel secure that future needs can be met satisfactorily.

Yet another standard fiscal impact which is more difficult to resolve stems from jurisdictional problems. The lack of coincidence between municipal boundaries and the area affected by the facility may produce a management problem. To deal with this situation, impact management programs must consider both the distribution of revenue and the overall level of revenue collected.

Special fiscal impacts involve such items as security arrangements for shipments. These too must be considered in negotiations and incorporated in impact management agreements. In the Process, the basic assumption made is that all such costs are absorbed in the costs of the actual siting process rather than being passed on to the community.

Social impacts

The standard social impacts of facility development vary greatly, depending on the type of community involved. For example, the impact of new arrivals is greatly magnified in small rural communities that have long social histories. New residents may reduce the feeling of informality and can change existing organizations, institutions and leadership. Obviously, it is extremely difficult to quantify the effect of this impact or suggest a way of compensating the volunteer community. On the whole, the new facility must be seen to offer benefits which outweigh the existing residents' perception that the community will change for the worse with the development.

The most significant special impacts are the social ones that result from the perceived special nature of radioactive wastes. People fear that the radioactive material will negatively affect their health and safety and that of future generations. As well, there are well-known concerns related to groundwater contamination and subsequent radiation exposure.

Residents have special concerns about the institutional arrangements for the management of the facility. They must be assured that provisions for long-term monitoring and compensation satisfactorily protect their health and welfare.

The management program must also consider the possible ''stigma'' effect on the residents of the volunteer community. Community involvement in the studies leading up to the development of the facility and in the ongoing programs associated with the facility in part address this potential negative effect. Compensation measures, and in particular reward measures, can also be used to counter the ''stigma'' effect.

The Task Force has reviewed the community impact management agreements used by Ontario Hydro with several communities.[30] They demonstrate that each of the standard and special impacts on volunteer communities can be addressed in a sound and responsive manner. The Task Force recommends them as a suitable base for the development of an impact management agreement between the federal government and the volunteer community.

This particular model is recommended because it allows not only for the up-front determination of standard impacts and the allocation of resources for necessary mitigation (so-called ''Station A'' accounts), but also provides for ongoing impact monitoring and contains a mechanism to mitigate special impacts as they emerge during the life of the project (''Station B'' accounts). Substantial funds are placed in Station B accounts before construction begins. This provides the community with the assurance it requires and reflects the true potential cost of the facility.

Also important in the Ontario Hydro model is the fact that the local community is involved in outlining the potential impacts and the monitoring program it considers important to its welfare. This role is a cornerstone of successful impact management. As a final point, this model establishes the use of an arbitration board with each party to the agreement appointing an equal number of members. To date, the arbitration arrangement has not been employed, a reflection of the success of the Ontario Hydro model in identifying standard and special impacts and providing for suitable management measures.

7.5 Potential impacts on communities with existing wastes

The discussion of impact management would not be complete without consideration of the effects of changes in waste management practices on residents in communities with existing waste accumulations. While the general types of impacts to be

considered could be drawn from the six categories outlined in the previous section, the specific impacts in any given community will vary depending on the management options chosen and the nature of each community. For example, if the removal of waste material to a central facility is considered desirable, a number of impacts might occur. These would be limited principally to economic, public services and fiscal classes.

Economic impacts

Depending on the volume of wastes to be removed and the routes used, local businesses could be adversely affected by truck traffic, noise, dust and congestion. Local employment is not likely to increase given that trucking and similar services are likely to be arranged with a firm or firms from the community that accepts and houses the new central facility.

Public services impacts

Potentially the most significant among the special public services impacts to be considered are the possible health effects to be dealt with. Clearly, any movement of radioactive waste at or from its storage site raises the possibility of adverse health effects. For example, the disturbance of soils, like those at Port Hope, which are contaminated with Radium 226 and its daughter products, leads in the short term to a substantially increased release of radon. However, when such a release occurs in the open air, the radon is likely to be dispersed rapidly, without any of the build-up of dangerous radon daughters that occurs when radon is released in a confined space. Another health concern applies to workers excavating low-level radioactive waste sites or transporting such waste. They may be exposed to some small increases in direct gamma radiation, particularly if "hot spots" are uncovered. Finally, as is the case in any large-scale earth moving and transportation operation, a certain number of workplace accidents totally unrelated to the nature of the material being moved must be anticipated.

There are, of course, numerous other potential public services impacts. For example, waste-removal vehicles could add to traffic problems. Given the definite, well-known time span of the removal operation, however, additional personnel to deal with such problems probably would not be required. Existing roads might require upgrading or restoration and, depending on the transport mode, transfer stations could be needed. Such costs should not be borne by the community; they should be paid by the party responsible for the wastes. On the other hand, the community should not be compensated for any additional administrative efforts involved with the waste removal activity because, over the years, the community received tax revenues as well as employment benefits from the operator who generated the waste. In addition, the community now stands to gain from the perceived benefits of getting rid of the wastes.

Fiscal impacts

Market values for land in affected neighbourhoods in the community may increase following the removal of the radioactive waste material and its perceived dangers. If this occurs, increased tax revenues would accrue to the community. This would be offset, however, by the reduction in any existing revenues going to the community from the waste sites that were decommissioned.

In general, for communities with existing low-level radioactive wastes, Task Force members do not recommend compensation for most special impacts or intangible costs. Direct payments or grants-in-kind add directly to overall project costs. They cannot be justified, given that such communities have benefited economically from the activities of waste producers for a number of years.

7.6 Impacts on communities along transportation routes

The removal of low-level radioactive waste material and its transportation to a new waste management facility mean that several communities may be affected. However, it is not likely that great economic, demographic or housing impacts will be felt in access-route communities. Therefore, impact evaluations and management programs for these communities will need to deal primarily with social, fiscal and public services impacts, and will need to be put in place, as appropriate, for each community along the selected transportation route.

The Process requires that each community receive complete information programs and be allowed to develop impact management plans to protect its welfare. These plans should focus on the temporary, high-volume movement of waste and on any longer-term ongoing waste transport issues. For example, concerns about emergency response measures and needs for increased traffic surveillance must be addressed. As well, training programs have to be considered, particularly for emergency crews. In addition, suitable insurance coverage (in terms of amounts and liabilities) must be determined and put in place. Finally, all costs associated with the upgrading or restoration of roads must be borne as part of facility-siting expenses, rather than local community expenses.

7.7 Impact management strategy development

As this brief assessment of the differing needs of each type of community in the siting process demonstrates, devising an appropriate impact management strategy will not be an easy task. Essentially, it will involve using a problem-solving process that requires careful assessment of potential impacts, both positive and negative, and a good understanding of the kinds of impact management options that can be put in place to manage impacts.

As discussed in the next chapter, the results of any site and technology assessments conducted in Phase four of the Process will provide the base of information that will identify the potential problems to be solved and benefits to be maximized. The siting guidelines that will be developed in Phase one of the Process will be designed to assist the communities involved in the siting process in developing appropriate impact management strategies and negotiating sound impact management agreements. (See Figure 15.)

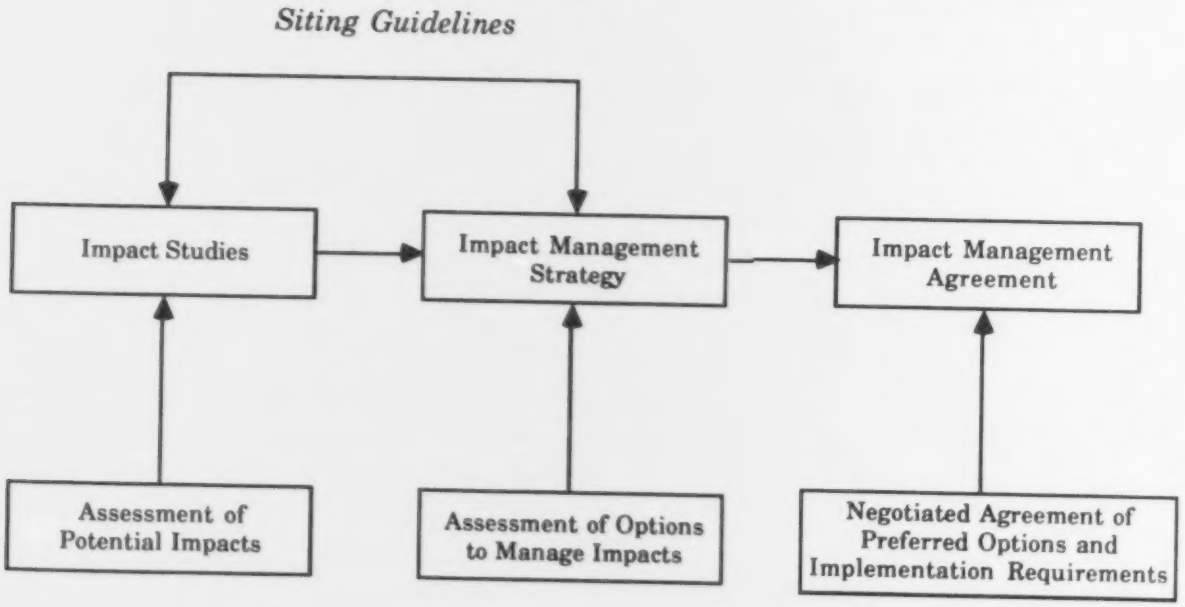
7.8 Organizational framework for implementation of the Process

A co-ordinating organization, called the Siting Task Force for the purpose of this report, will need to be established to ensure that the principles of the recommended Process will be respected and that none of the safeguards will be overlooked in siting a facility. Additionally, this body will have to ensure that the facility siting costs remain within the budget, whatever amount that might be. The budget will be determined by Cabinet.

The co-ordinating organization could be structured in a number of ways, if the primary responsibility for the implementation of the Process were to remain with the federal government. In such a case the organization could be designated as a commission, a working group, or an agency. As was the case with the Siting Process Task Force, members will be appointed by the Minister responsible for low-level radioactive waste management issues.

Figure 15

Impact management strategy development


Siting Guidelines
Impact Studies
Impact Management Strategy
Impact Management Agreement
Assessment of Potential Impacts
Assessment of Options to Manage Impacts
Negotiated Agreement of Preferred Options and Implementation Requirements

7.9 Conclusions and recommendations

We recommend that "voluntary acceptance" be adopted as the basic procedural principle for the process of siting of a low-level radioactive waste management facility.

Further, we recommend that the emphasis given to technical assessments of management options and their potential impacts be counterbalanced by the legitimization of an active, joint decision-making role for potentially affected communities. Communities and their potentially affected residents should be regarded as full partners in the process.

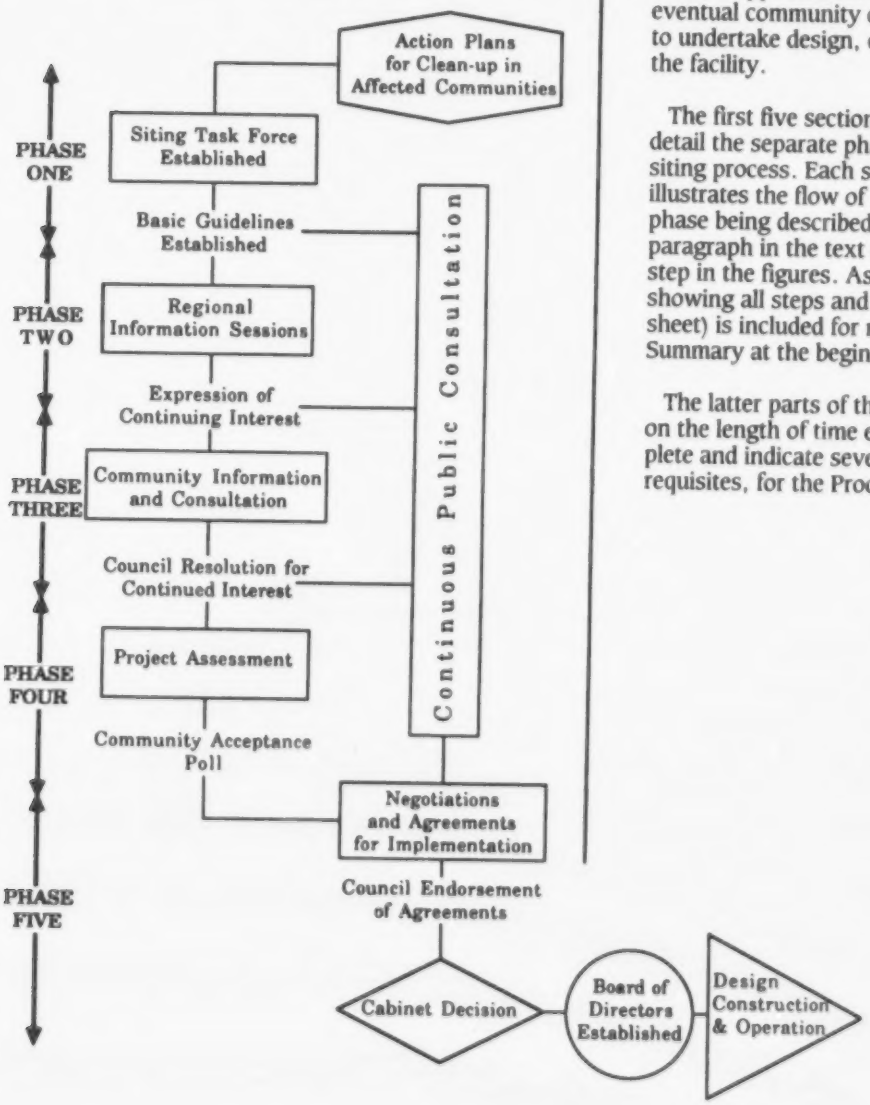
We also recommend that the siting process ensure that the community accepting the facility is compensated in a way that offsets all costs and that it leaves the community better off than it was previously in acknowledgement of the service that the community is providing.

The potential for social disruption in the siting of a low-level radioactive waste management facility extends beyond potential candidate communities to include communities where such wastes now exist (and where relocation of the wastes is being considered) and to communities located along access routes. The waste management process must be responsive to the concerns of all such communities affected by low-level radioactive waste management activities.

Chapter eight
Process description

Figure 16

A consultative siting process



The Process developed and recommended by the Task Force is summarized in Figure 16. In five distinct phases, the Process moves from the initial Cabinet appointment of a Siting Task Force to the eventual community choice of a Board of Directors to undertake design, construction and operation of the facility.

The first five sections of this chapter outline in detail the separate phases of the recommended siting process. Each section presents a figure that illustrates the flow of the siting process steps in the phase being described. Further, each numbered paragraph in the text corresponds to a numbered step in the figures. As well, a full Process diagram showing all steps and their projected timing (on one sheet) is included for reference in the Executive Summary at the beginning of this report.

The latter parts of this chapter provide information on the length of time each phase might take to complete and indicate several implications of, and prerequisites, for the Process.

8.1 Phase one: Establishing guidelines

During the work of the Task Force to develop a more co-operative siting process, members reviewed several background documents that had been prepared to provide information on various aspects of radioactive waste management (e.g., the existing inventory and estimated continuing production of radioactive wastes in Ontario; transportation issues associated with moving the wastes; and the radioactive waste disposal technologies that could be used in the province). In addition, a paper was produced on impact management factors for volunteer communities. While these reports had limited circulation to obtain comments to help the Task Force establish the report's validity, they have not received broad public review or discussion. Nonetheless, it was on the basis of these reports that members concluded that the management of low-level radioactive waste in Ontario could be improved.

Because this conclusion remains to be verified, the first phase of the Process for finding a site for a low-level radioactive waste disposal facility must include a public review of the reports. This exercise has the added benefit of helping to promote a broader understanding of the issues of low-level radioactive waste management.

There are five basic steps in the guidelines phase.(See Figure 17.) Each is now described in some detail.

Step 1.1
Independent expert review of background reports

To carry out this review by independent experts, the background reports are circulated to individuals and organizations that have appropriate, recognized technical expertise. This distribution also includes waste producers and government regulatory agencies such as the Board, MOE, DOE and NH&W. The Siting Task Force then consolidates the views of these experts on the acceptability of the documents covering waste management technologies, the transportation methods and the impact management guidelines.

Step 1.2
Public review of background reports

The Siting Task Force also invites written comments on the background reports from interested individuals and groups. This is done by conducting a province-wide media campaign to publicize the availability of the reports, by distributing copies of the reports to people who respond to the campaign and by distributing copies province-wide to people and groups known to be interested in the subject.

Step 1.3
Draft guidelines

Based on the responses received from both reviews, the Siting Task Force prepares draft guidelines for siting and impact management. These guidelines help communities assess their potential to house the required facility. The draft guidelines then are submitted to government agencies for their review to ensure consistency with regulatory standards and public policy. The draft siting guidelines set out the basic principles to be followed, the roles of the key players, the characteristics of suitable sites, and the available technologies. The draft impact management guidelines indicate the options that compensation can take and how it is determined. These draft guidelines are circulated to individuals of record.

Step 1.4
Siting Task Force holds public meetings

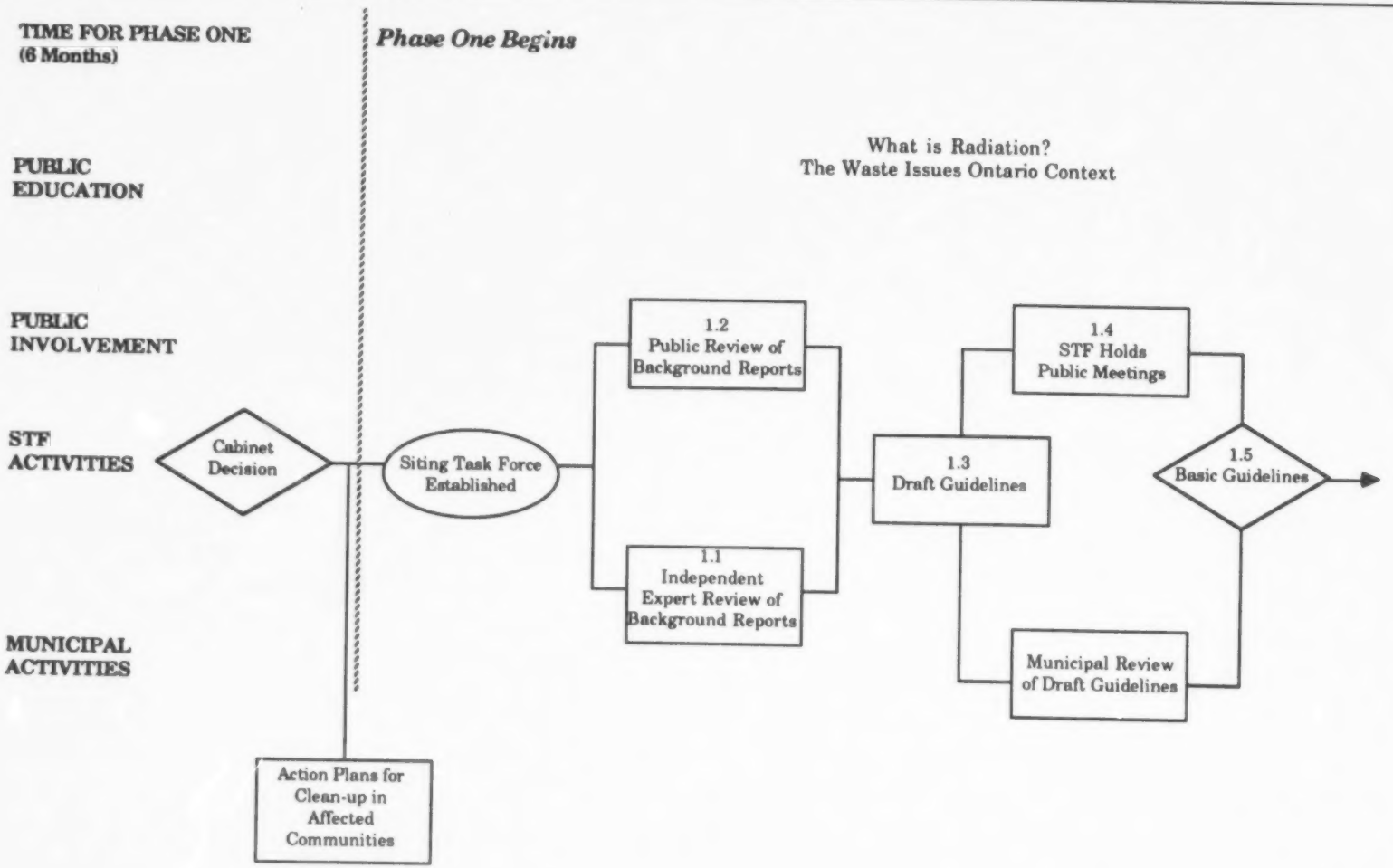
The Siting Task Force then holds a series of public meetings to present the draft guidelines, to respond to questions, and to receive comments. These meetings are held in appropriate locations based on the responses received in Step 1.2.

Step 1.5
Basic guidelines

Phase one concludes with the Siting Task Force finalizing the siting and impact management guidelines.

Figure 17

Phase one — Establishing guidelines



8.2 Phase two: Regional information sessions

Because the recommended Process is such a significant departure from traditional site selection approaches, it is necessary in beginning phases to carefully explain the Process steps and ensure that the public fully understands the co-operative nature of the Process and the roles of all key groups and individuals in it. There must also be public discussion and education concerning the characteristics of low-level radioactive wastes and the technologies available for their management. For these reasons, provision is made in Phase two for the Siting Task Force to conduct a series of regional information sessions across the province of Ontario, at locations that coincide as much as possible with provincial land use planning districts. (See Figure 18.)

The regional sessions begin the actual siting process by outlining:

- the need for improved waste management practices;
- the nature of the materials involved;
- acceptable technology options;
- economic, social and environmental considerations;
- safety measures; and
- the proposed siting process.

Special attention must be given to the self-identification, volunteer and opt-out features of the Process. Finally, the guidelines established in the first phase of the Process are also provided and explained. Information sessions involve four steps as next outlined.

Step 2.1
Regional profiles

To begin, regional profiles are prepared using available information. This ensures that the Siting Task Force can appreciate the concerns and characteristics of each region and, thus, is able to provide information that addresses specific regional interests. With the assistance of the local representatives of the provincial Ministry of Municipal Affairs, a list of possible participants from each region is compiled that includes a cross-section of community leaders having different interests and backgrounds. Such lists are to include representatives from various Chambers of Commerce, economic development officers, community planners and medical officers of health. Assistance and co-operation from other provincial ministries will be needed to ensure the success of this stage of the Process.

Step 2.2
Regional sessions

The regional sessions are held by invitation at convenient locations within each area. They are conducted in a workshop setting with small groups to promote the fullest possible exchange of information. The sessions also employ educational aids such as videos, brochures, displays and models. Any related travel expenses incurred by participants to attend each session are reimbursed by the Siting Task Force.

In this stage special attention is paid to media representatives. Explanations of the basic principles to be followed in the siting process, and technical information on waste management and safe disposal options are provided in media briefings, prior to each regional session.

Step 2.3
Letter inviting indications of interest

Following the regional sessions, letters inviting indications of interest are sent to all regions, districts and municipalities in the province. Each letter with its attachments is addressed to the Clerk or Chief Administrative Officer and explains the Siting Task Force mandate, the need for and characteristics of a low-level radioactive waste management facility, and the Process, highlighting its principles and guidelines. The opting-out feature of the Process also is emphasized. As well, comments received from the regional sessions are noted. The letter concludes by stating that if a municipality is interested in receiving further information, representatives can contact the Siting Task Force.

Step 2.4
Expression of continuing interest

It is expected that some municipalities are likely to request further information, while others are not. Those formally expressing interest are involved in the next phase.

Figure 18

Phase two — Regional information sessions

TIME FOR PHASE TWO
(2 to 6 Months)

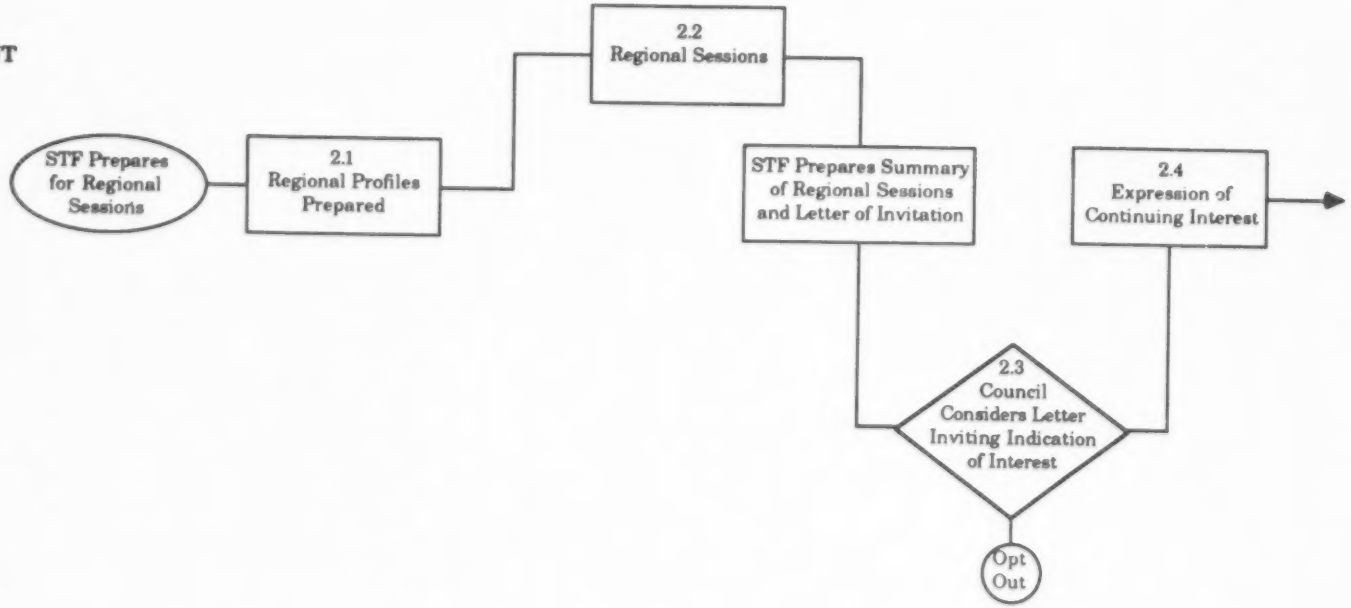
PUBLIC EDUCATION

Regional Media Briefings and Continuing Public Education

PUBLIC INVOLVEMENT

STF ACTIVITIES

MUNICIPAL ACTIVITIES


STF Prepares for Regional Sessions
2.1 Regional Profiles Prepared
2.2 Regional Sessions
STF Prepares Summary of Regional Sessions and Letter of Invitation
2.4 Expression of Continuing Interest
2.3 Council Considers Letter Inviting Indication of Interest
Opt Out

8.3 Phase three: Community information and consultation

For ease of description, this phase (see Figure 19) is discussed in two stages although, in reality, elements of each may well occur at the same time. In the first stage, council information sessions (steps 3.1 to 3.4) are held for those municipalities that express their interest in learning more about the low-level radioactive waste management project and the siting process. Community profiles are prepared, information sessions are held and an indication of continued interest is obtained as applicable. Municipal councils play the key role in this stage in guiding the Siting Task Force.

The objective of the second stage (steps 3.5 to 3.7) is to inform the residents of the community of the project and the siting process. To assist the Siting Task Force and the council with this, a community liaison group is established. Through a consultative process, attempts are made to ensure that all interested and potentially affected people obtain full information, are given the opportunity to express their views and have their concerns addressed. In addition, during this stage the Siting Task Force informs people of the scale of the project, the technology options available and the possible benefits. Before they can proceed to Phase four, local councils must provide a resolution confirming their continued interest in the siting process.

Step 3.1
Profile interested communities

Community profiles help the Siting Task Force to better understand the concerns and characteristics of each interested community. Building on material obtained at the regional sessions, these profiles provide a list of formal and informal community leaders and a framework for conducting preliminary information sessions. This information, as outlined in Table 8, comes from a number of available sources and from discussions with community group leaders, the local media and service agencies.

Step 3.2
Information sessions

Information sessions are conducted to describe the major elements of the Process. As in the previous phase, the use of small work group sessions in a public setting is likely to be the most effective format, although the Process is not limited to this means of public involvement.

The emphasis at these information sessions is on explaining the nature of the radioactive materials to be handled, the potential risks and the role of the community and key players in the Process. As well, the established guidelines for siting and compensation are explained. The number and timing of information sessions are governed by the needs of each community, as determined by each local council. Similarly, local councils decide what participants to invite to these sessions. Task Force members proposed these sessions primarily as a means of addressing the council, its staff and other community leaders.

Table 8

Siting Process Task Force General community profile check list

Specifically, this list will have to be adapted to the particular type of community, i.e., city, town, village, police village, township, county or a northern Ontario administrative district. The Task Force's reference to a regional profile is to be identified, e.g., regional municipality, eastern Ontario, etc.

1 Population (census data)
2 Ethnic mix
3 Industry/rural/tourist mix
4 Bedroom community %
5 History of community stability

6 Elected officials
7 Municipal or regional
8 Provincial MLA
9 Federal MP
10 Appointed officials; clerk, planning, etc.

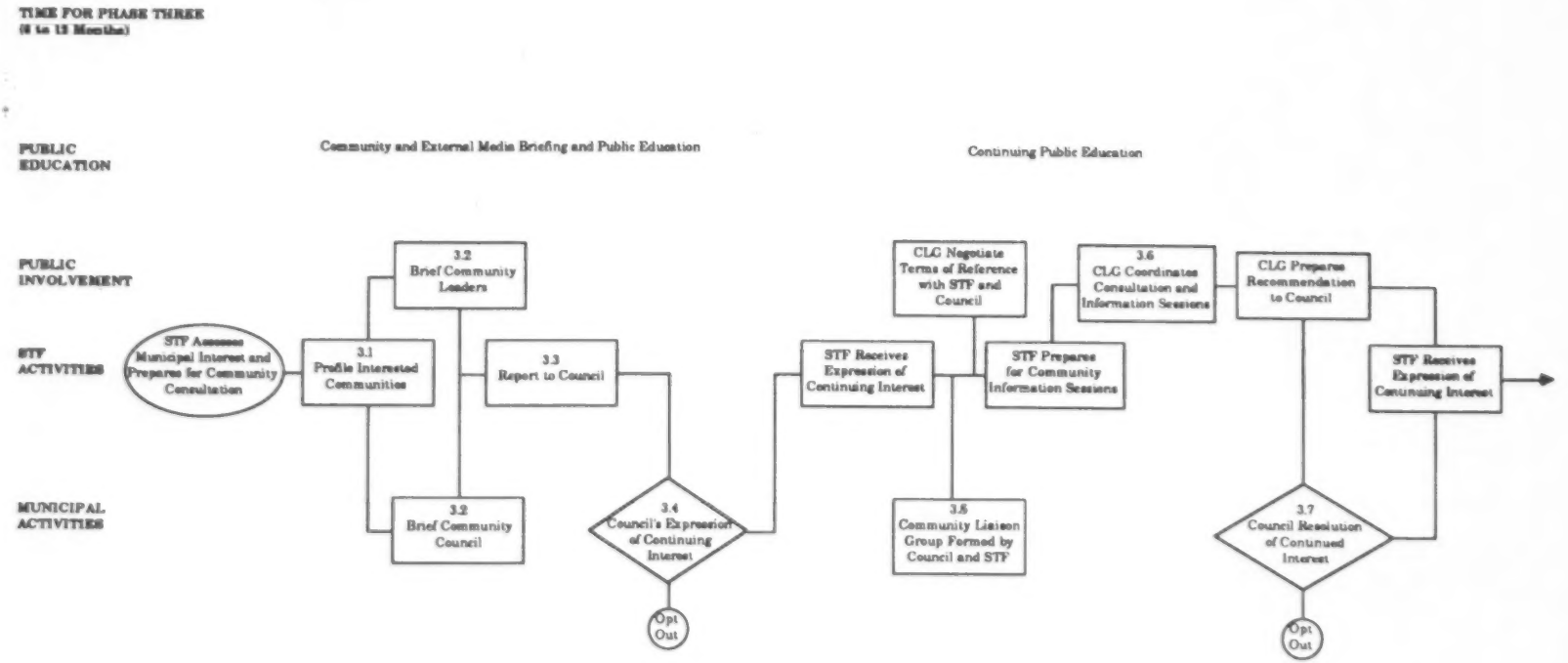
11 Business and social organizations; key source contacts
12 Churches
13 Service clubs
14 Women's institutes
15 Agriculture associations
16 Labour unions

17 News media; key source contacts
18 External impact media
19 Daily newspapers
20 Weekly newspapers
21 Television stations
22 Radio stations

23 Community organizations; key source contacts
24 Environmental groups
25 Patterns of activity

Figure 19

Phase three — Community information and consultation


TIME FOR PHASE THREE
(6 to 12 Months)
PUBLIC EDUCATION
Community and External Media Briefing and Public Education
Continuing Public Education
PUBLIC INVOLVEMENT
STF ACTIVITIES
MUNICIPAL ACTIVITIES
STF Assesses Municipal Interest and Prepares for Community Consultation
3.1 Profile Interested Communities
3.2 Brief Community Leaders
3.2 Brief Community Council
3.3 Report to Council
3.4 Council's Expression of Continuing Interest
Opt Out
STF Receives Expression of Continuing Interest
CLG Negotiate Terms of Reference with STF and Council
STF Prepares for Community Information Sessions
3.5 Community Liaison Group Formed by Council and STF
3.6 CLG Coordinates Consultation and Information Sessions
CLG Prepares Recommendation to Council
3.7 Council Resolution of Continued Interest
Opt Out
STF Receives Expression of Continuing Interest

Step 3.3
Report to council

Once the Siting Task Force concludes the information sessions in each community, it prepares a public report and submits it to each municipal council. This report summarizes the information sessions and reports on issues or concerns raised. It also describes, in detail, the next steps of the Process. More specifically, it documents the need for a Community Liaison Group and the role that group plays in the remainder of the siting process. Each report concludes with a request for a letter confirming both the council's continued interest in a facility and its commitment to the Process, including its principles and guidelines.

Step 3.4
Expression of continuing interest

Local councils that feel their municipalities do not have the physical characteristics necessary to meet the siting criteria, or feel that such a facility is not of interest to them, can opt out of the Process at this stage. Those who remain must advise the Siting Task Force, by resolution of council, of their continued interest and their commitment to establish a Community Liaison Group.

Step 3.5
Community Liaison Group appointed by council

The next task is the actual establishment of a Community Liaison Group. This group is appointed by council with assistance from the Siting Task Force and comprises a cross-section of the community. It plays an important role as the community focus in this and subsequent phases of the Process. Independent of, but accountable to, council and the Siting Task Force, it helps ensure that residents' concerns are brought forward and that decisions taken in the Process are widely representative of the community. Members of the Community Liaison Group are paid an honorarium, based on the average amounts paid to other groups or committees in the local area. The terms of reference of the Community Liaison Group, including such items as term of office, reporting relationships, decision-making powers, and expected results are established by negotiation between the municipal council and the Siting Task Force.

At a later stage in Phase four, the Community Liaison Group, jointly with the Siting Task Force, hires advisors and commissions the studies determined to be essential for the community to:

- understand the waste management proposal;
- develop an appropriate set of site selection criteria;
- analyze the physical characteristics of the area;
- select possible sites and technology options;
- identify and quantify potential environmental and socio-economic impacts; and
- design suitable impact management measures for those impacts considered significant.

As part of the Process, the Siting Task Force Secretariat provides technical expertise to ensure that any studies undertaken are both appropriate and of consistent quality. Funding for studies is provided by the federal government through the Siting Task Force.

Step 3.6
Consultation and information sessions

Unlike the information sessions conducted in the previous phase (which were general in nature), community information sessions in this step provide specific information about the scale of the project, technology options, possible benefits, mitigation measures and compensation policy. Attention focusses on the siting guidelines; the Siting Task Force seeks community-specific refinements to those guidelines. To ensure effective two-way communications, each session uses a consultative method adapted to best fit the situation. In the view of the Siting Process Task Force, the use of small groups is the most effective approach.

These sessions are co-ordinated by the Community Liaison Group with assistance from the Siting Task Force. The Community Liaison Group considers the approach to information exchange it feels is most effective. Among possible options are: setting up drop-in centres or a local siting information office; making presentations to local service clubs; and promoting discussion of the siting process on community radio and television stations.

At the conclusion of the consultation and information sessions, the Community Liaison Group publicly presents its findings and makes a recommendation to the council regarding continued involvement in the Process.

Step 3.7:
Council resolution of continued interest

The final step in Phase three requires receipt of a council resolution to indicate that the municipality wishes to remain in the Process.

8.4
Phase four: Project assessment

As with the previous phase, Phase four (see Figure 20) is divided for descriptive purposes into two stages, although in practice they may tend to overlap to a certain degree. The two stages are grouped together because they both employ the techniques of joint fact-finding and problem-solving to accomplish their objectives.

The objectives of the first stage (steps 4.1 to 4.3) are to select the technologies, identify preliminary sites, identify potentially significant environmental and socio-economic issues and find ways to manage these issues. This stage results in one of two outcomes: either there are no suitable sites found in the community, in which case the community receives no further consideration, or field investigations confirm the availability of potential site(s) and the technology to use at those sites.

If a potential site is located and if the community is still interested in being considered for the facility, then the Process moves to steps 4.4 through 4.10. Detailed technical, economic, environmental and social studies are commissioned to assess the feasibility of developing the site. This is the most intensive and potentially expensive aspect of the siting process. As these studies become available, their results and expert comment on them are circulated for full public review and discussion so that concerns and issues needing further study are identified and resolved in a timely manner. The transportation options also are explored and decided on, followed by consultation with potentially affected communities. After all this is done, the acceptability of the overall proposal is measured by a public opinion poll. If the results of this process and poll are positive, they are confirmed later by another resolution of council.

Step 4.1
Site and technology identification

Those communities that choose to continue working with the Siting Task Force begin identifying suitable sites and preferred technologies. Because this Process recognizes that technology selection is not simply a technical decision, community consultation plays an important role in this step in identifying community preferences regarding technology. General and technology-specific guidelines and criteria (developed in earlier steps) are further refined, in consultation with the community, and are applied to the available sites, first to undertake preliminary screening and then to identify an actual site. This work uses existing information and is jointly coordinated by the Community Liaison Group and the Siting Task Force Secretariat (hereafter referred to as the Secretariat), with guidance from the Siting Task Force. For sites under active consideration, next come pre-feasibility engineering studies that determine the compatability of preferred technologies with the proposed sites. In addition, potential environmental and socio-economic impacts are identified along with possible measures to effectively manage them. Subsequently, appropriate field work is conducted to verify findings.

Step 4.2
Community discussion

After the preliminary investigations to identify suitable sites and technologies, specific sites are proposed. Upholding one of the basic principles of the Process – that a technically undesirable site cannot be accepted – unsuitable sites are excluded from further consideration by the Community Liaison Group and the Siting Task Force. The remaining site and technology options are presented jointly by the Community Liaison Group and the Secretariat to the community for general discussion. The form of these presentations emulates those approaches to public consultation already found effective during Phase three.

Step 4.3
Council commitment to detailed assessment

The Siting Task Force prepares a report on the preliminary assessment and community response for consideration by council. Council, in consultation with the Community Liaison Group, assesses the report before deciding whether to volunteer, on behalf of the municipality, as a candidate for the facility. Given the level of expenditure and effort involved in the remainder of the Process, the Siting Task Force decides with which municipalities it can continue to work, based on such criteria as the availability of technically sound proposals and the strength of community support. Voluntary withdrawal from the Process also occurs at this stage.

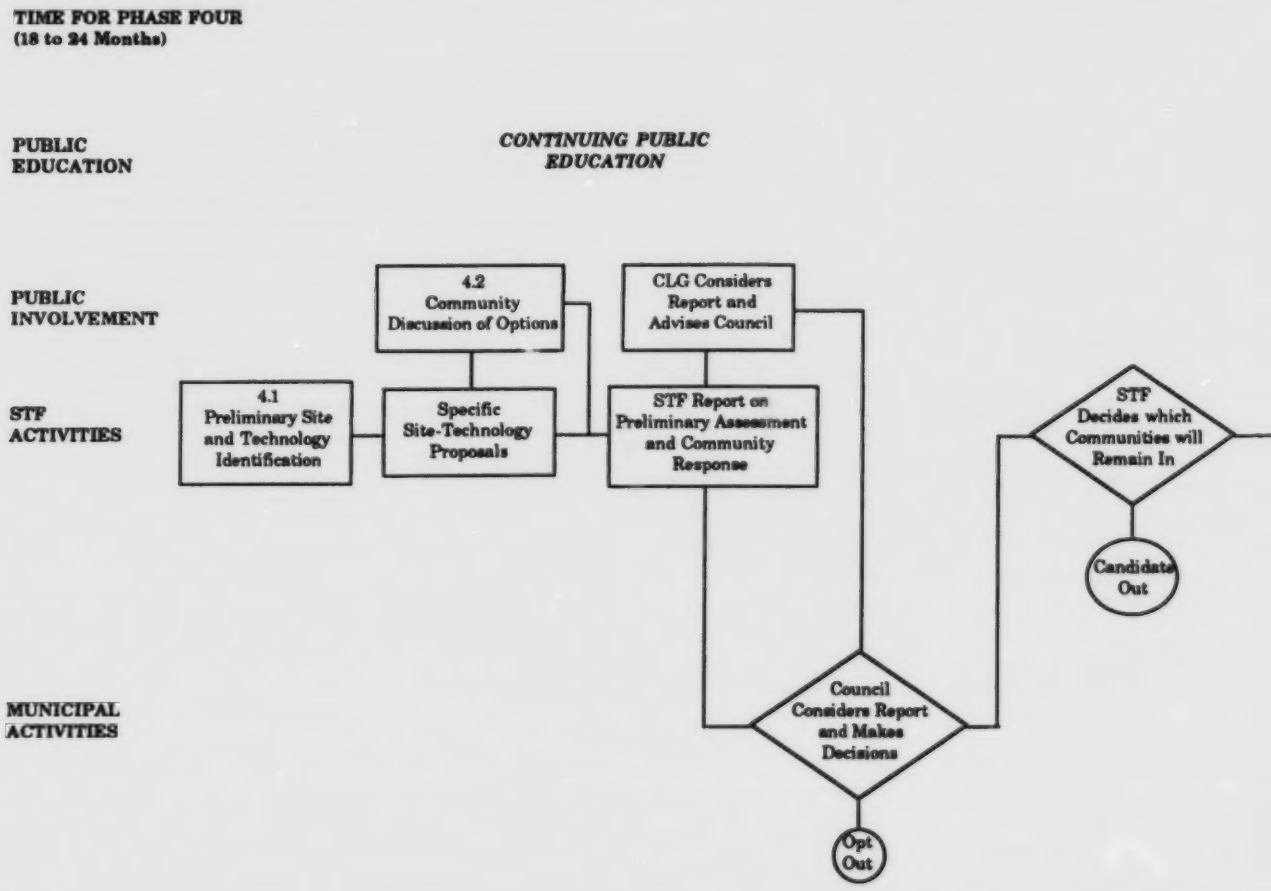
Step 4.4
Identify issues/prepare terms of reference

The siting process proceeds to a detailed evaluation of those proposed facilities which meet the basic siting guidelines and criteria. This evaluation begins with a community-specific discussion of the issues that relate to each potential site and its technology. This scoping exercise identifies the key issues, their extent, their relative importance and the studies required to assess them.

Together, the Community Liaison Group and the Secretariat, with the guidance of the Siting Task Force, develop terms of reference for tendering necessary contract work, for evaluating submissions, and for reviewing the study results. Furthermore, they establish the way in which the results of the studies are distributed.

Figure 20

Phase four — Project assessment


TIME FOR PHASE FOUR
(18 to 24 Months)
PUBLIC EDUCATION
CONTINUING PUBLIC EDUCATION
PUBLIC INVOLVEMENT
STF ACTIVITIES
MUNICIPAL ACTIVITIES
4.1 Preliminary Site and Technology Identification
4.2 Community Discussion of Options
Specific Site-Technology Proposals
STF Report on Preliminary Assessment and Community Response
CLG Considers Report and Advises Council
Council Considers Report and Makes Decisions
Opt Out
STF Decides which Communities will Remain In
Candidate Out

Step 4.5
Evaluation of environmental impacts, technical issues, cost-benefit analysis and social impacts

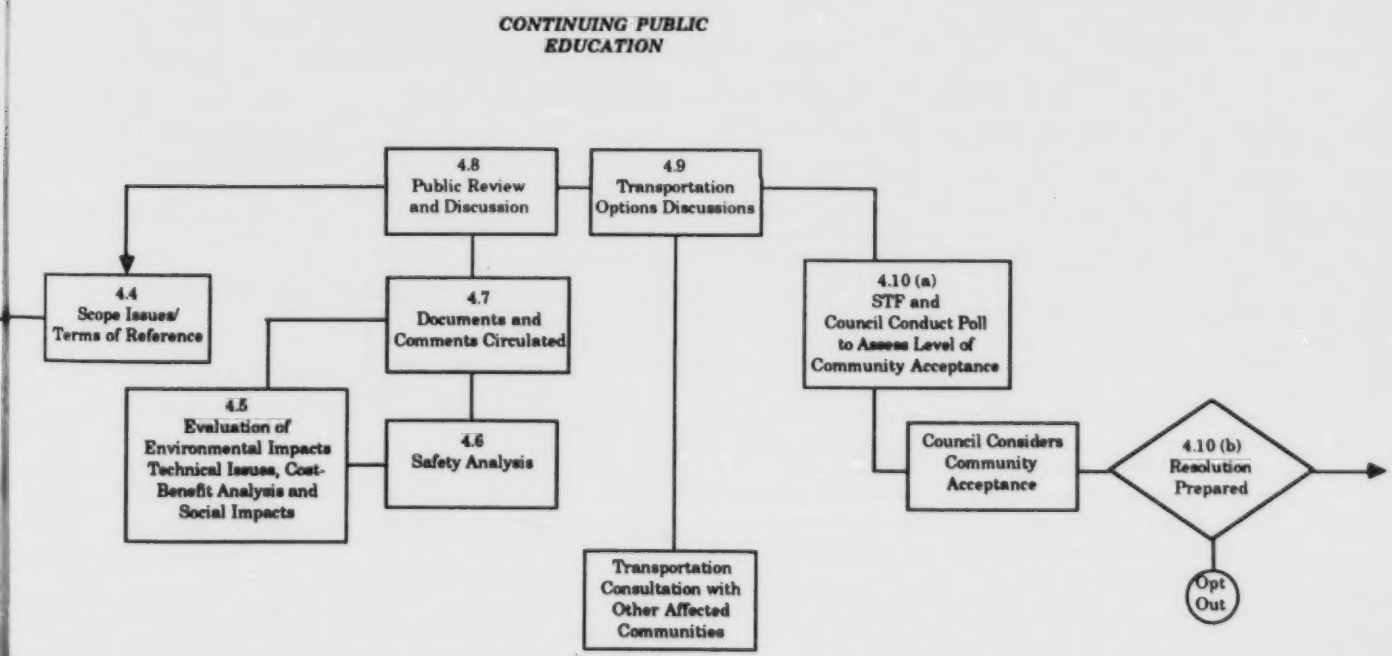
Tenders are let for studies on the basis of the jointly developed terms of reference. Once the work is carried out, the results of the environmental, technical, economic and social assessments are analyzed by the Community Liaison Group, the Secretariat, and the Siting Task Force. This evaluation work includes identification of requirements for impact management.

Step 4.6
Safety analysis

Ensuring the safety of any proposed facility is one of the fundamental principles of the Process. To respect this principle, the environmental evaluation, including technological analyses, is submitted for safety assurance reviews by relevant government departments, agencies and regulators (e.g., the Board, the Ontario Ministry of the Environment, and the federal departments of the Environment, and National Health and Welfare) as well as independent private sector consultants, the waste producers and other interest groups.

Step 4.7
Documents and comments circulated

As the final reports from each of the studies commissioned in step 4.5 are received, they are circulated within the community. They also are sent to the relevant federal departments and provincial ministries, the waste producers, and any other groups identified by the Community Liaison Group. In addition, as comments are received on these reports they are compiled and similarly distributed. An overall summary of the findings also is prepared


CONTINUING PUBLIC EDUCATION
4.8 Public Review and Discussion
4.9 Transportation Options Discussions
4.4 Scope Issues/ Terms of Reference
4.7 Documents and Comments Circulated
4.10 (a) STF and Council Conduct Poll to Assess Level of Community Acceptance
4.5 Evaluation of Environmental Impacts Technical Issues, Cost-Benefit Analysis and Social Impacts
4.6 Safety Analysis
Council Considers Community Acceptance
4.10 (b) Resolution Prepared
Opt Out
Transportation Consultation with Other Affected Communities

and accompanies the report on the safety analysis. Sufficient time is set aside to ensure that informed discussion of the material can take place at the community level.

Step 4.8
Public review and discussion

As the study reports, comments and summary findings are completed and reviewed, opportunities must be provided by the Community Liaison Group and the Secretariat for the community and any interested groups or individuals to raise, in a timely manner, any issues or concerns they feel were not adequately addressed in the assessments. For example, interested parties may request more detail on certain topics, seek other opinions or present arguments that run contrary to conclusions drawn by any of the studies. The objective of this step is to address outstanding concerns in a co-operative fashion. Based on information submitted or gained through further study, the Siting Task Force and Community Liaison Group determine whether any problems indentified are so significant that the facility proposal should be rejected.

Step 4.9
Transportation discussions

As Phase four nears completion, if the community is positive about housing the facility, attention focusses on the available transportation options to move the waste material to the facility. If truck or train haulage is expected to be direct from point-of-origin to destination, the Siting Task Force establishes, with the help of the Community Liaison Group, an information-consultation program for affected communities along the major transportation routes. Where a multi-modal approach is the most effective, extensive information exchange, consultation and negotiation sessions are held with communities in which a transfer site might best be located and with access-route communities. Small community liaison groups may be formed and given support by the Siting Task Force to ensure that each community acquires adequate understanding of the important issues associated with transportation of radioactive wastes. The Community Liaison Group representing the volunteer community also plays a major role in this step, since the successful siting of the transfer site is crucial to the proposal from the volunteer community.

Step 4.10
Community acceptance — poll and resolution

For those proposed facilities that remain under consideration, this step measures the level of community acceptance of the proposal. Once the community is satisfied that an adequate amount of information was assembled and that the pertinent issues and concerns were adequately discussed and dealt with, then ongoing support for the proposal is tested through an independent public opinion poll commissioned jointly by the Siting Task Force and the local council.

Following the public release of the poll results (assuming they indicate community endorsement of the proposed facility), the council is asked to pass a resolution confirming its continued interest in having the proposed facility developed in the community and agreeing to enter into formal negotiations with the Siting Task Force to develop an impact management agreement.

8.5 Phase five: Implementation

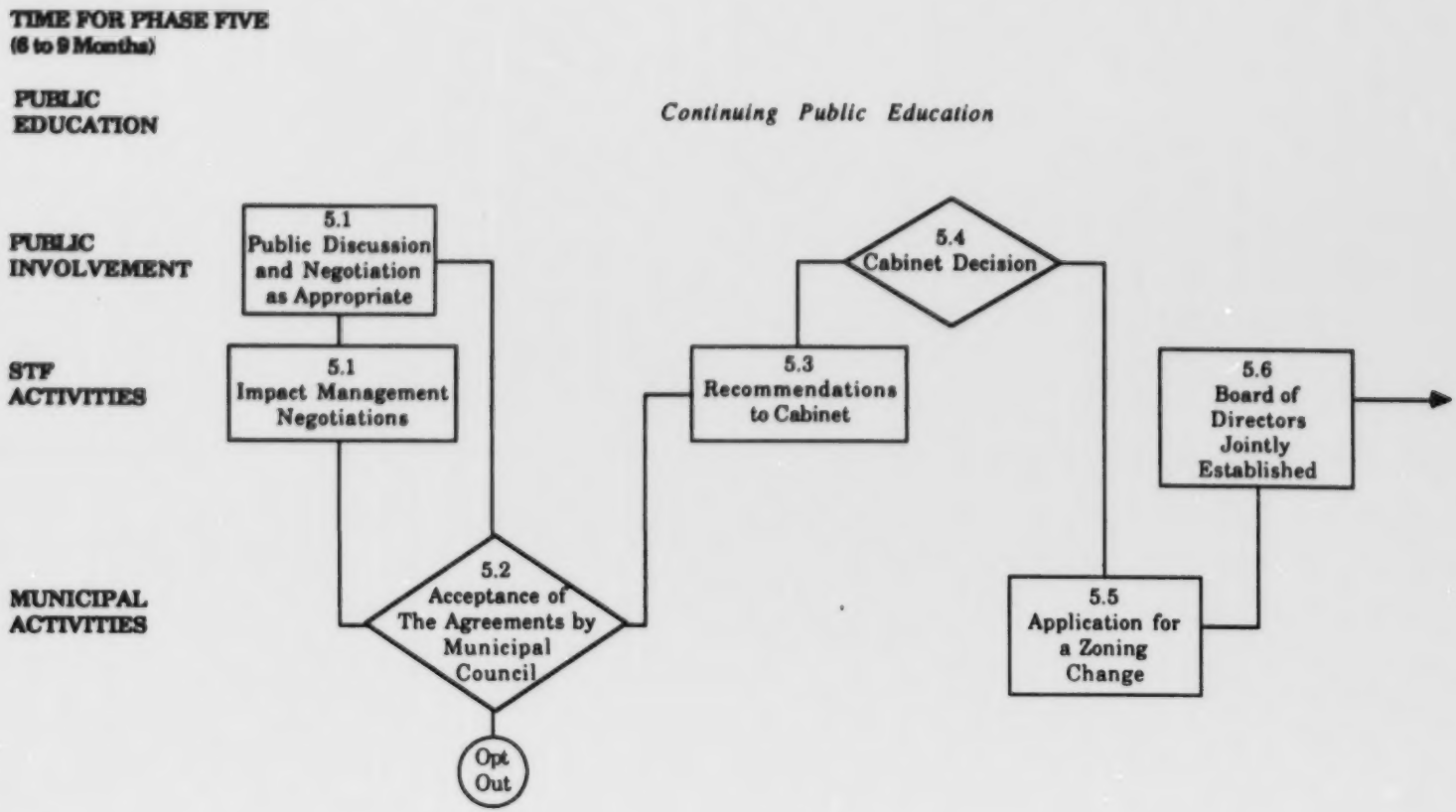
Phase Five of the Process (see Figure 21) involves intensive community negotiations on specific impact management measures, followed by a recommendation to Cabinet and a Cabinet decision. The decision is followed by required land use planning activities such as zoning or official plan amendment applications in the successful community. The siting process ends with the establishment of a Board of Directors to oversee the final design, construction and operation of the facility. This Board of Directors reports to the Minister of the Crown responsible for the facility.

Step 5.1
Formal impact management negotiations and tentative agreements

Community negotiations in the implementation stage address the host of impact management options outlined previously in this report. In addition, the Siting Task Force ensures that the volunteer community is fully aware of any other features that have not been identified already in discussions. Agreement is reached on items such as the eventual purchase by the Crown of the necessary land, the determination of the distribution of payments in lieu of taxes which may be forthcoming and any land value protection agreements. As well, local employment guarantees, tippage charges and short- and long-term liabilities are specified. The community also negotiates pre-construction financial guarantees to ensure that specified safety performance is achieved.

Figure 21

Phase five — Implementation



In terms of the ongoing operation of the facility, community negotiations also serve to develop and document the long-term arrangements. These include such items as: the procedures for the selection of members for the board of directors for the facility; and the development of a management plan, a monitoring program, emergency response and contingency plans, and financial guarantees tied to long-term liabilities.

The community's role in determining actions to be taken in the event of premature closure of the facility is addressed at this point. Additionally, the terms and conditions surrounding the closure and post-closure phases are agreed upon.

Where inter-modal transportation is to be used, a tentative agreement is reached with the community in which the transfer site will be located. While on a smaller scale, many of the factors that enter into the negotiation are similar to those mentioned previously for the community where the facility is to be located.

In these and all subsequent negotiations, the Siting Task Force negotiates on behalf of the federal government, while the Community Liaison Group and the municipal council negotiate on behalf of the community. In addition, the Siting Task Force negotiates agreements with affected individuals as required.

Step 5.2
Acceptance of the agreements by municipal councils

Once the tentative agreements are negotiated, they are presented to the community council for public endorsement. Following this endorsement, council passes, at its discretion, a final resolution requesting Cabinet to consider developing a facility on the proposed site in its community.

Step 5.3
Recommendation to cabinet

The Siting Task Force prepares reports detailing each of the proposed facility options for consideration by the federal Cabinet. These reports must include: a cost-benefit analysis of the proposals; a summary of the detailed impact management agreements; budgetary considerations; technical summaries; environmental and social impact assessments; a safety analysis; a chronology of community discussions; issue papers; and the results of the independent polls. The Siting Task Force also ensures, prior to reporting, that all proposed facilities are evaluated in accordance with the principles of the siting process and that all Process safeguards are exercised.

Step 5.4
Cabinet decision

Cabinet reviews the reports on all the sites put forward that have gone through the Process. In the event that there are options, Cabinet decides which is the preferred facility proposal. It also decides on the amount of money to be allocated for the project and empowers the Siting Task Force to finalize the agreements on behalf of the federal government.

Step 5.5
Application for a zoning change

The community for which the facility plan is approved makes arrangements for any necessary official plan amendments and zoning changes.

While it is unlikely at this late stage in the Process that a community would choose to opt out, if this happened, Cabinet could exercise its authority to negotiate with any alternate community that had asked for the facility, had gone through the siting process, and had been put forward for consideration.

Step 5.6
Board of Directors established

Following Cabinet approval of the final negotiated agreements, a Board of Directors is selected jointly by the Siting Task Force and the community. This board conducts the business of the facility and implements the provisions of the impact management agreements.

Initially, the Board of Directors has specific responsibilities for overseeing the administration of the facility and advising the government on such matters as final design and construction of the facility, development of the infrastructure and implementation of the impact management plans. It also performs a liaison role, providing a forum for the local community to continue its involvement in the management and operation of the facility.

The Board of Directors is made up of representatives of the community (4), the waste producers (1), the federal government (chairperson) (1), and the provincial government (1). The operator of the facility functions as the president of the facility corporation and is hired by, and reports directly to, the Board of Directors. The Board of Directors reports to the Minister of the federal department responsible for low-level radioactive waste management.

8.6 Timing

The proposed siting process is unique. Siting Process Task Force members know of no similar process that could be used as a benchmark to estimate the time required to carry out each phase. However, some parts, such as step 4.5 (the evaluation of environmental impacts, technical issues, cost-benefit analysis and social impacts), are very similar to features of other processes that have been in use for some time. Making use of similarities wherever possible and, when they did not exist, using its collective judgement, the Task Force now presents estimates for each phase, excluding formal decision-making time. However, it must be stressed that the time required is not only dependent on the tasks to be done, but also on the resources allocated to carry out the tasks. Because of this, members present the range of times that each phase may be expected to take. On average, other forms of waste-siting processes have taken approximately five to seven years to complete – excluding the public hearings process, which can add on another one or two years. The opportunity for full public review is built into the times suggested for the phases of the Process.

The timeframes are:

- Phase one – 6 months
- Phase two – 2 – 6 months
- Phase three – 6 – 12 months
- Phase four – 18 – 24 months
- Phase five – 6 – 9 months

These estimates, of course, are affected by elections at all levels of government because of the time that can be lost (i.e., the learning-curve) by new process participants. In addition, the timing for Phase three is influenced by the number of communities that show an interest in the siting process. Given fixed Secretariat and Siting Task Force resources, the greater the number of communities involved, the longer it will take to complete this phase. Finally, there is nothing in the Process that stipulates that all communities must begin at the same time or go through the Process at the same pace. The only critical time – the time when all groups must come together – is at the Cabinet decision step.

8.7 Implications of the Process and prerequisites for its implementation

The proposed Process constitutes a significant departure from traditional facility siting methods. It seeks to change the nature of interactions between the participants and, by so doing, change the very nature of the mechanics of the process of siting facilities. In part, the success of this Process depends on the extent to which its inherent positive potential is realized. Additionally, the success in implementing the Process depends largely on the willingness of the key participants to modify their attitudes and adopt different ways of interacting.

The traditional concept of facility "proponent" does not apply in the Process. While the proposed facility will be owned by the federal government, there is no agency designated in advance as the operator that will act as the proponent for the facility. Certainly, the Siting Task Force does not play this role. Its mandate is to oversee the siting process and the Task Force's credibility in this regard depends on its non-proponent status. The operator of the facility will not play the proponent role because the operator is not even determined until Phase five, at which point a Board of Directors is jointly selected by the Siting Task Force and the community. Only after this does the Board of Directors hire its choice of operator. While the operator is responsible for managing and maintaining the facility on a day-to-day basis, the Board of Directors, accountable to a Minister of the Crown, makes all executive and general administrative decisions. Although the Board of Directors, given its role, might be seen as the proponent, the lateness of its appointment in the Process precludes it from playing the traditional proponent role.

The decision not to designate a proponent in the Process was deliberate. Task Force members see the absence of a proactive proponent, and hence concern with justifying a specific proposal, as an important Process feature, because it helps change the dynamics of the siting process, moving it from confrontation to co-operation. Members believe it will reduce the need for defensiveness on the part of all parties and facilitate a more collaborative approach to problem-solving and decision-making.

Because there is no proponent, the role of the local council as the official representative of the community in the voluntary Process necessarily becomes proactive. Rather than being in a position of reacting to and/or defending the community from a proposal, the Process assigns to the council an active role in the overall development of that proposal. It is expected, moreover, that because the council communicates directly with the community about the proposed facility and participates in the joint problem-solving activities, decisions will be made in a more timely fashion than in traditional processes where councils have been at arm's length from proponents. Not only does the role of the municipal council change in the Process, so does that of general interest groups.

Rather than having to direct their efforts toward intervening on behalf of the community (a role such groups play when siting decisions are imposed on local communities), general interest groups have the opportunity to provide an invaluable service to both the community and the Siting Task Force by cooperatively participating, not only in the issue identification (a strength they clearly have), but also in the more creative and taxing process of developing solutions.

The roles and responsibilities of government experts also must change in the Process. Experts within such agencies as the Departments of the Environment and of National Health and Welfare must deal directly with the citizens of the volunteer communities in a joint problem-solving process. Affected citizens can discuss their concerns directly with experts and get expert help in resolving issues to everyone's mutual satisfaction. Citizens can establish close, long-lasting ties with these agencies to get their expertise, knowledge and help if and when needs arise.

Fundamental changes are also needed in the regulatory agencies governing the management of low-level radioactive waste. Specifically, Task Force members feel that the practices of the AECB, while adequate in the past, should be reassessed to ensure that they truly reflect the evolving sociopolitical context and take into account increases in knowledge that the nuclear sector has witnessed over the years. Members are not convinced that the current approach to regulating the nuclear industry in regard to low-level radioactive waste management serves the general public as well as it might. For example, a more definite and consistently applied set of standards to govern waste management is certainly attainable and clearly preferable to what now exists. The current practice of placing the onus on waste producers to develop, for given waste sites, their own clean-up criteria and then submit these for review and modification by the Board is tantamount to the Board abdicating what rightly is, and should remain, its responsibility.

Clearly, there are many ways to address the issues and problems of low-level radioactive waste management. There are no absolute solutions. For varying reasons, any given site requires consideration of a choice of technologies and transportation methods, all to be assessed, at least in part, on the basis of the volume and characterisics of the waste. Disposal is not the only possible approach to radioactive waste management. The arguments supporting disposal without long-term institutional controls have not led the Task Force to endorse that option as the sole solution. Thus, the Board should be receptive to a broader discussion of waste management options.

There is no provision for a separate, formal public hearing at the end of the Process. There is no need to incorporate, as a separate phase, this type of formal review. The Process, from beginning to end, provides for full public involvement, review and joint decision-making. Step 4.8, as outlined earlier, is particularly important in this regard because it provides an opportunity for public discussion of both the detailed site assessments and the expert comment on them. In effect, it constitutes a thorough public review process as envisaged by the provisions of the federal Environmental Assessment and Review Process.

If sufficient concern remains following Phase five of the Process, then the community can always exercise its right to opt out. Since there is no attempt to impose a decision on a community, there is no need for an independent panel to review the merits of such a decision. Indeed, the establishment of such a "panel" at the end of the siting process would not only be inappropriate, but also financially irresponsible.

The appropriate management strategies acceptable to those communities which currently have waste deposits must be determined before the Siting Task Force commences the Process for siting a facility for low-level radioactive wastes. It would be a mistake to assume that the communities now housing waste deposits have acquired a full knowledge and understanding of the impacts associated with radioactive wastes and their clean-up. Nor can it be assumed that they have an understanding of the various options available to them in dealing with the problem. It is necessary to further educate and inform communities so they can participate effectively in developing plans of action. The strategies adopted for the management of wastes in each of the communities with accumulations are essential to determining the location, scale and type of the waste facility. It is critical, therefore, to hold discussions with these communities and develop action plans prior to initiation of the Process.

Accordingly, Task Force members propose that an independent group hold this responsibility and enter into joint problem-assessment and solution-identification exercises with residents of affected communities. The development of action plans with these communities should comprise three main phases:

In Phase A, the independent group contacts, in each affected community, the elected officials (through the Chief Administrative Officer) and requests a meeting to explain and discuss the need to develop a waste management plan. Among the agenda items discussed at such a meeting are:

- regulatory guidelines;
- volumes, levels of activity, characteristics and locations of the waste deposits;
- full scale versus partial clean-up (possible volumes of traffic, physical ramifications, existing road conditions, traffic routes, etc.);
- in situ management (as an option); and
- the course of action to be followed within the community to implement the management plan.

In Phase B, the independent group holds community information sessions and makes available to the public the same information it provided to the elected members of the municipality. This is done through open houses, general community meetings and community neighbourhood workshops. Meetings can be structured so that small groups of people get together in informal sessions to gain a better understanding of problems and possible solutions, and offer their thoughts and feelings on the best way to deal with the issues. As well, the independent group commissions any additional research or reports deemed necessary by the community and the group to answer questions and allow them to make informed decisions about the waste management strategy they wish to adopt. The results and recommendations from these activities are presented publicly to the municipal council by the independent group. Once council acceptance is obtained, the group presents its findings to the appropriate Minister of the Crown for approval.

In the final phase, the independent group and each affected municipal council jointly develop general guidelines for any necessary clean-up and rehabilitation. These general guidelines are discussed with affected neighbourhoods to develop detailed management plans that take into account all zoning requirements and land-use planning. These final detailed management plans, once approved by council, are given to the appropriate agency for implementation.

8.8 Conclusions and recommendations

We recommend that the five-phased Process be adopted as proposed, and implemented with its underlying principles upheld, and the safeguards applied.

Because the approach to facility siting which we are advocating is novel, there is no model upon which to base estimates of the time that will be required to carry it out. We have attempted to make a reasonable projection of the period of time necessary to complete each phase. Excluding any allocation of time for formal decision-making, we have calculated a variable timeframe to complete the Process of 38 to 57 months, depending on resources available to fulfil the various functions in each phase.

The traditional role of "proponent" is not incorporated into the Process which is predicated upon a community volunteering to accept a waste management facility. As a result, the dynamics of the siting process change from confrontational to co-operative.

Based on there being no proponent, the local council officially representing the community necessarily must be prepared to assume a more proactive role in the overall proposal development.

We recommend that, in adopting the Process as we have designed it, Cabinet launch an investigation into the need for and feasibility of changes in the roles and responsibilities of government experts and regulators falling under federal jurisdiction and that provincial counterparts be encouraged to do likewise.

We recommend that Cabinet authorize the initiation of plans of action to determine the waste management requirements of all communities currently housing low-level radioactive wastes. These action plans would be carried out jointly by an independent group (with members to be selected by the federal government or one of its agencies) and representatives of the communities in question. Together, they would assess the extent of any management problems, and devise solutions to the problems identified.

A final word

At the beginning of our task, we were conscious of the many uncertainties that characterize the problem of low-level radioactive waste management. As our work progressed, it became increasingly clear that much of the conflict and controversy which surrounds waste management initiatives stem from decision-making processes that are seriously flawed. Essentially, the general public has been excluded in large measure from these processes and, consequently, has become cynical and untrusting of governments, the nuclear industry, and the regulatory agencies responsible for establishing and enforcing safety standards. This situation has been compounded by a classification system for low-level radioactive wastes and an approach to safety regulation which do little to engender public understanding and confidence.

We fully appreciate the far-reaching nature of the decisions that face all countries that use radioactive materials in medicine and industry, especially with respect to management of radioactive waste. We are convinced, however, that gaining public acceptance of, and support for, waste management initiatives will require a fundamental reorientation of the decision-making process, from top-down technocratic procedures toward open and collaborative problem-solving.

The matters which we were asked to address have a long and contentious history. Our investigation has convinced us that, though low-level radioactive waste management and facility siting issues will not be easily resolved, they are far from insurmountable. There is much that can be done to improve the current situation. However, for this to be realized, there must be a willingness to question conventional wisdom, reassess current procedures, and risk charting new directions.

In preparing this report, we have not aimed for comprehensive coverage of the subject. Rather, we have placed our emphasis on problem identification, and the critical reassessment of such major issues as the role of the public in site selection, the role and responsibilities of municipal councils, the policies and procedures of the appropriate regulatory authorities, and the safety of existing technologies for containment, transportation, and general management of low-level radioactive wastes.

Throughout our work, we have benefitted immeasurably from the knowledge, expertise and insight of many individuals, groups and organizations interested in the site selection process. We are grateful for their contributions.

The carrying out of our research and the preparation of this report have required extraordinary diligence and dedication from support staff. Sincere thanks for many long hours of work are extended to Secretariat members Bob Greyell and Lorraine Gailey. We mention with special appreciation the unstinting labours of our secretarial staff.

We are grateful for the opportunities we have had as members of the Task Force, opportunities to broaden our own horizons, and, we hope, to guide the site selection process onto the road to co-operation. We wish our successors well.

Appendices

A Prime Minister's letter to Port Hope area residents

B Low-level radioactive waste policy

C 1 Honourable Allan Lawrence's October 10, 1986 Port Hope announcement of the redirection of low-level waste disposal process
2 Honourable Gerald S. Merrithew's December 11, 1986 announcement of an independent Task Force

D Radiation, radioactivity and health

E Glossary of terms

F Task Force Letter to DOE, MOE, NH&W, and AECB

G Response to Task Force letter

H Assumptions for the determination of transport cost estimates to move the low-level radioactive wastes out of the Port Hope area

I References identified by numbers in text

J Bibliography

Appendix A

Prime Minister's letter to Port Hope area residents

CANADA

LEADER OF THE OPPOSITION - CHEF DE L'OPPOSITION

Ottawa, K1A 0A6
August 21, 1984

Mr. James Sculthorpe,
R.R. No. 3,
Port Hope, Ontario.
L1A 3V7

Dear Mr. Sculthorpe,

Thank you for your letter outlining your concern about the proposed permanent disposal site for low-level radioactive waste in the vicinity of Wesleyville, Ontario.

As you may know, The Honourable Allan Lawrence, Progressive Conservative M.P. for Durham-Northumberland, is strongly opposed to any such proposal and has been pressing the federal government to remove all such waste to a permanent isolated location, distant from any centres of population and from any significant water systems.

As Mr. Lawrence stated recently, there is ample evidence that neither of the current proposals by Eldorado Nuclear Limited for establishing a permanent radioactive waste disposal dump either near Port Granby or near Wesleyville are acceptable to the people of those communities or to their elected representatives. All such waste should be removed from major population areas and kept well away from any major water resource such as Lake Ontario.

While this would involve greater expense, the federal government, as owner of the Eldorado Nuclear Limited, must accept at least partial responsibility and provide the leadership.

For several years federal authorities have been exploring where and how to store permanently Canada's growing accumulation of nuclear and radioactive waste. The waste from Eldorado Nuclear Limited must be considered part of that problem and its solution.

I appreciate being advised of your concern about this matter which, I know, is shared by many Canadians. You can be assured that a Progressive Conservative government will work most actively towards a safe, acceptable and permanent storage arrangement for all hazardous wastes.

With every good wish,

Yours sincerely,

Brian Mulroney

Appendix B

Low-level radioactive waste policy

NEWS RELEASE

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

86/67
April 25, 1986

MINES MINISTER RELEASES FEDERAL POLICY ON MANAGEMENT OF LOW LEVEL RADIOACTIVE WASTES

The Honourable Robert E.J. Layton, Minister of State for Mines, today released a statement outlining the federal government's policy on the management of low level radioactive wastes. The statement also defines the respective responsibilities of the federal government and the producers of the waste material. The policy is intended to be used in the development of solutions for the permanent disposal of low level radioactive wastes.

The policy of the federal government is to ensure that low level radioactive wastes will be dealt with in such a way that:

- human health and environment will be protected now and in the future;
- social as well as economic factors will be taken into account.

Low level radioactive wastes are produced in many different industrial, medical and research operations. The major quantities are produced from the manufacturing and power generating stages of the nuclear fuel cycle. Significant quantities derive from medical diagnoses and treatment in hospitals, and from general industrial and research applications of radioactivity.

On the question of responsibility, the government has adopted the principle that the costs of waste management must be borne by those benefitting from the generation of the wastes.

"Thus, the primary responsibility for the management of radioactive wastes, including disposal, must rest with the producers of such wastes," the statement says.

It recognizes, however, that in some circumstances – for example, when waste has been generated by a company that no longer exists – "governments must accept a residual responsibility for the wastes for which no person or company can any longer be held responsible."

Canada

more -

The federal policy statement emphasizes that "no compromises on the levels of safety required by the regulatory bodies will be permitted."

The policy statement applies only to low level radioactive wastes for which the federal government accepts residual responsibility. It does not address the important role of the provincial governments in this area. The cooperation of the provincial governments in low level radioactive waste management is the subject of ongoing negotiations.

The federal policy also stresses the importance of cooperation on the part of the public, industry, and all levels of government in the determination of disposal sites.

- 30 -

For further information, contact: Joe Howieson
Advisor, Radioactive Waste Management
Energy, Mines and Resources Canada
(613) 995-1118

86/67(a)

Federal Policy on the Management of Low Level Radioactive Wastes

This document is issued in order to clarify the principles and define the policies that the federal government will apply to the management of low level radioactive wastes. The document also defines the responsibilities of the federal government and of producers of low level radioactive wastes. This federal policy will be applied to all facets of low level radioactive waste management including the development of disposal facilities for existing wastes.

1. Policy

It is the policy of the federal government to ensure that low level radioactive wastes will be dealt with in such a way that

- human health and the environment will be protected now and in the future;
- social as well as economic factors will be taken into account.

2. Corollaries

The statements in this section derive from this policy with specific reference to the siting and licensing of disposal facilities for low level radioactive wastes.

(a) While many factors must be taken into account in developing a safe and reliable disposal facility, human health and safety and environmental protection are of primary importance. No compromises on the levels of safety required by the regulatory bodies will be permitted.

(b) The geology of the disposal site can make an important contribution to safety, however, appropriate combinations of engineering controls and constraints may be used to help provide the necessary level of safety and environmental protection in many different geological settings.

(c) The disposal facility must provide sufficient isolation of the wastes from the biosphere to ensure that current and future populations and their water supplies will be protected.

(d) The health and safety of workers and the public must be taken into account for all waste disposal activities, including transportation.

(e) An important socioeconomic principle that applies to siting is equity. One aspect of equity requires that areas benefitting from the industry that produces the waste should share some of the responsibility for its safe disposal. However, equity may also require that an area that hosts a safe disposal facility obtain offsets for doing so.

(f) Societal concerns such as land use, local growth patterns, and cost effectiveness, must be taken into account when choosing the site and the manner of disposal.

(g) Following from the primary responsibility of the waste producers (defined in Section 3 following), producers, among others, may propose disposal facilities and sites. If a preliminary assessment conducted by a proponent in consultation with the Atomic Energy Control Board indicates that a site and facility can meet the safety objectives, then early consideration of the site by government is warranted. Such consideration should include detailed public and regulatory scrutiny of the site and facilities proposed in order to ensure that they meet the federal government's requirements. The final decision on siting rests with the federal government.

(h) To obtain low level radioactive waste disposal facilities in the most efficient and effective manner, the cooperation and participation of the public, waste producers, and local and provincial governments is desirable.

3. Responsibility

The basic principle that governs responsibility in this area is that the costs of waste management must be borne by those involved in the generation of the wastes. Thus, the primary responsibility for the management of radioactive wastes, including disposal, must rest with the producers of such wastes.

It is recognized that in some circumstances, governments must accept a residual responsibility when no person or company can any longer be held responsible for the wastes. These circumstances include: (a) the cleanup and disposal of historic wastes; (b) small producers not in a position to develop their own disposal facilities; (c) companies no longer in business; and (d) long-term stewardship of disposal sites once they have been closed out to the satisfaction of the regulatory authorities.

This residual responsibility may require the government to take actions that will result in the disposal of historic wastes, in the provision of commercial disposal facilities, and in the performance of the long-term stewardship role for closed-out disposal facilities.

The residual responsibility of the federal government is derived from the Atomic Energy Control Act and Regulations, and applies to low level radioactive wastes produced from: (a) activities in the nuclear fuel cycle (from uranium refining, through nuclear reactor operation, to disposal); (b) activities involving the intrinsic use of the radioactive properties of materials; and (c) safeguarded materials. Producers of low level radioactive wastes within the federal area of responsibility are subject to Atomic Energy Control Regulations under the Atomic Energy Control Act.

The federal government created the Low Level Radioactive Waste Management Office in Atomic Energy of Canada Limited, to perform the functions resulting from this federal residual responsibility. The office has been asked to deal with the historic wastes as a priority. The cooperation of the provincial governments in dealing with low level radioactive wastes is the subject of ongoing negotiations.

4. Background

At this time, radioactive wastes in Canada are being stored safely. To date, no low level radioactive wastes have been consigned to permanent disposal. For those low level radioactive wastes that have no potential recoverable values, permanent passive disposal is desired by the producers and the government.

The accumulated low level wastes and associated contaminated soils that are being stored today amount to some 1 000 000 m^3. Many of the operations that

produced these wastes in the past are now eliminated, and many of the currently produced wastes are being recycled. As a result, the quantities of wastes projected to arise in the future will be small: only about 10 000 m^3 per year.

The low level radioactive wastes in Canada span a large range of radioactivity concentrations and of decay periods. Technologies for the disposal of such low level radioactive wastes have been demonstrated using long-term projections in many countries and these technologies have been put into practice in several countries. The methods in current use include landfills, shallow burial, and disposal in constructed caverns in various geological settings, with the choice being related to the intrinsic properties of the various types of wastes. In addition to the natural containment of the wastes provided by the local geological features, various levels of engineered isolation have been provided at existing facilities.

Engineered barriers or restraints can be used if necessary to enhance the properties of the local geology. In some circumstances, engineered constraints can be used on their own to provide the necessary isolation period for the radioactivity to decay to innocuous levels regardless of the local geology.

The benefits from the nuclear industry are diffused throughout society, while the perceived detriments from waste facilities are concentrated in very specific areas. Thus, the ideal democratic principle – that preference should be given to courses of action resulting in the greater good for the greater number of people – is not widely accepted in practice by residents who happen to live near a proposed waste disposal facility.

The federal government is sensitive to both societal needs and local perceptions. The federal government must act in the best interests of society and it is confident that this can be achieved while protecting local interests.

Definitions

For the purposes of this document, the following definitions apply:

Radioactive Waste is defined as any material containing or contaminated with radionuclides in concentrations greater than would be considered acceptable for uncontrolled use or release to the environment and for which there is no foreseen use.

Low Level Radioactive Wastes are all forms of radioactive wastes except those deriving from uranium or thorium mining and milling operations (mostly uranium tailings at present) and from irradiated nuclear fuel.

Historic Wastes are those low level radioactive wastes that were managed in the past in a manner no longer considered acceptable but for which the original producer cannot reasonably be held responsible.

Management of Radioactive Wastes means all steps from the production, collection, processing and transportation of these wastes, to their storage and disposal. The investigation of problems and necessary remedial work, including decontamination of properties, is also part of the management role.

Disposal is a permanent method of management in which there is no intention of retrieval and which, ideally, does not rely for its success on the continued need for institutional controls beyond a reasonable period of time.

Disposal would be achieved when the wastes are sufficiently isolated by natural or engineered passive containment, or sufficiently reduced in concentration by radioactive decay or dispersal, that the residual risks to human beings and the environment are acceptable.

Storage is a temporary method of management using containment and isolation in a manner that incorporates provision for retrieval and that relies on the continued need for human intervention and surveillance, whether this be for monitoring, maintenance, treatment, or restriction of public access.

Appendix C

1 Honourable Allan Lawrence's October 10, 1986 Port Hope announcement of the redirection of low-level waste disposal process
2 Honourable Gerald S. Merrithew's December 11, 1986 announcement of an independent Task Force

NEWS RELEASE

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

86/180
October 10, 1986

PORT HOPE LOW LEVEL WASTE DISPOSAL PROCESS REDIRECTED

PORT HOPE – The Honourable Allan Lawrence, Member of Parliament for Durham-Northumberland, announced that the Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines), who is lead Minister responsible in Cabinet for low level radioactive waste disposal issues, has requested his colleague, the Honourable Tom McMillan, to delay the Environmental Assessment and Review Panel hearings on the Port Hope low level radioactive waste issue.

Mr. Lawrence also announced that his colleague, the Honourable Barbara McDougall, the Minister responsible for Eldorado Resources Limited, has been requested to direct Eldorado to stop work on its two site proposals for a permanent low level waste disposal facility in the Port Hope area.

Eldorado will be directed to drop from further consideration its recently announced Newcastle North site, near Tyrone in the Town of Newcastle. This land is considered by Mr. Lawrence and the Government of Canada to be valuable agricultural land. Eldorado has indicated that it will allow its options for the purchase of these lands to expire.

At Mr. Lawrence's request, Eldorado is also being directed to set aside consideration of its Wesleyville site for the immediate future.

Mr. Merrithew has reaffirmed the federal policy on the management of low level radioactive wastes. He also indicated his strong support for the Federal Environmental and Assessment Review Process and its role in ensuring that public and environmental safety are protected now and in the future in the establishment of any such waste facility.

Mr. Merrithew said he was taking these actions today because he recognized that recent public concern was focused on the site selection process and that the methods used to date were not achieving the desired result.

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The Minister said, "I am not in support of confrontational processes, and, in fact, entered politics with the intent of trying to get communities and industries to work together to solve their common problems. Through the representations that have been made to me recently, not only from the public within the Port Hope area, but also from industry, and based on reviews of other governments' practices, it has become obvious to me that a broader number of factors need to be considered in siting such a facility. These local concerns have been forcefully presented to me by the local member of Parliament, Mr. Lawrence."

Problems of waste disposal have become an issue facing governments around the world. One experience in Alberta resulted in a process that met with community acceptance and a workable solution. In order to benefit from such successes, Mr. Merrithew announced today that he is forming a Task Force to report back to him in the shortest possible time on:

1) the most promising technologies for low level waste disposal,
2) the most promising areas within the province to utilize those technologies, including transportation and cost considerations, and
3) the most promising approaches for site selection that might be employed within the Province of Ontario.

This group will work together with the public and private sectors within Port Hope and its surrounding areas, and with other communities and industries throughout the province to get ideas on how to solve this problem and to investigate the possibility of finding communities which would have an interest in hosting such a facility. The Minister underlined the fact that the problem will continue to exist in the local area, and that local citizens must play an active role in solving the problem.

He also indicated that no further action would be taken on the Wesleyville site until the Task Force has reported and has given full consideration to other possibilities for waste disposal.

- 30 -

For further information, please contact: Jim McTaggart-Cowan
Energy, Mines and Resources Canada
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NEWS RELEASE

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

86/215
December 11, 1986

MERRITHEW ANNOUNCES INDEPENDENT TASK FORCE TO STUDY NEW APPROACH TO WASTE SITE SELECTION PROCESS

OTTAWA – The Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines), today announced the appointment of an independent seven-member Task Force on Low Level Radioactive Wastes that will examine and recommend a process that will lead to the selection of a site for a disposal facility in Ontario.

At a news conference in Ottawa, Mr. Merrithew introduced members of the Task Force and reaffirmed the federal government's policy to resolve the question of safe, long term disposal of low level radioactive wastes and soils.

"I informed the citizens of Port Hope on October 10 that I would create an independent Task Force to examine a broad range of options for site selection of low level radioactive waste disposal facilities in Ontario," the Minister said.

"The creation of this Task Force gives me great reason to hope that we will be able to resolve this challenge in a spirit of cooperation, rather than setting communities and government against each other. This hope is supported by the calibre of people we have attracted.

"Today, I am proud to announce that seven outstanding persons have agreed to serve on this independent Task Force."

Members of the Task Force include:

- Audrey Armour, Assistant Professor in Environmental Studies, York University, who has a wide range of experience and expertise in environmental, social and energy conservation issues;
- Dr. Michael Chamberlain, Chief of Nuclear Medicine, University Hospital, and Professor and Chairman, Division of Nuclear Medicine, at the University of Western Ontario in London, who has published extensively in the field of medicine;

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- Gerard Gervais, a professional urban and regional planner with experience in industrial and economic development and project management, currently a principal of the Maxion Corporation in Markham, Ontario;
- Marilyn McHolm, a long-time resident of Port Hope with many years of municipal government experience;
- Dr. James McTaggart-Cowan, Director, Office of Environmental Affairs, Energy, Mines and Resources Canada, who will serve as the Task Force coordinator;
- Dr. Arthur Porter, Professor Emeritus of Industrial Engineering, University of Toronto, who served as chairperson of the Royal Commission on Electric Power Planning in Ontario, and who has a distinguished public service and academic career;
- Paul Rennick, Senior Environmental Management Consultant in Burlington, Ontario and formerly a Director, Environmental Assessment Branch, Ontario Ministry of the Environment.

Mr. Merrithew explained that the Task Force's primary mandate will be to investigate the most promising approaches for site selection that might be employed within the Province of Ontario.

In support of the ultimate goal of site identification, and in preparation for the application of the process, it will also examine the most promising technologies for low level waste disposal, and the most promising areas within the province to utilize those technologies, including transportation and cost considerations.

The Minister reiterated that a key premise underlying the Task Force's mandate is that a waste site selection process must be one of cooperation and not of confrontation.

"The only way we can resolve this challenge is by working together, rather than against each other," Mr. Merrithew said.

"Using this approach, even I was surprised at how easy it was to attract some of the best minds in the country to work with us," the Minister said.

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The Task Force will report its recommendations to the Minister within eight months. Its Terms of Reference were developed in consultation with national and international government agencies and private industries with experience in the field. Citizens in the Port Hope area were also consulted.

- 30 -

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backgrounder attached

86/215 (a)

BACKGROUNDER

TERMS OF REFERENCE FOR MINISTERIAL TASK FORCE ON SITING A LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY

The Government of Canada recognizes the need for an improved process for the siting of low-level radioactive waste disposal facilities. The Task Force is therefore requested to design a cooperative process for facility siting which will have as its central objective the voluntary identification of one or more host communities each with a suitable disposal technology. The process must be capable of reducing confrontation and achieving a measure of public support.

The central focus of the Task Force's efforts shall be the process for siting a disposal facility within Ontario for the existing, on-going, and historic wastes in the Port Hope area. However, where it may be advantageous to the process, consideration should be given to including the disposal of other existing and ongoing low level wastes located within the Province.

The Task Force shall, in six to eight months time, submit to the Minister of State (Forestry and Mines) a report which will, as a minimum:

a) describe and analyze the processes which have been used to site controversial facilities in other jurisdictions nationally and internationally;

b) describe a recommended process for this project and explain how it is intended to meet the overall objective;

c) define what is meant by a host community, identify techniques which can be used to measure the level of acceptance by the public of such a proposal in a community, and recommend the criteria to be applied to determine the degree of acceptance;

d) address the economic framework for community discussions, and identify costs, benefits and opportunities associated with facilities siting. An attempt should be made to address the nature and quantification of appropriate levels of economic offsets that may need to be associated with such a facility;

e) examine and comment on the possible constraints or implications on site selection such as population density, land use, and water resources;

f) examine and comment on the possible constraints or implications of transportation to remote sites and the positive and negative consequences of more than one disposal facility in the province;

g) identify the existing policies, legislation and regulations related to the management of low level radioactive wastes, and list the government agencies responsible. Comment on possible implications or changes which may be necessary to the policies, legislation, or regulations to assist in facility siting;

h) present a communications plan and the introductory communications module which will allow for the implementation of the next stage of the recommended process;

i) recommend an organizational structure, identify opportunities for public involvement, and suggest responsibilities for design and construction in later phases of the siting process.

In order to understand the nature of the problem, the Task Force shall, by reviewing existing information and augmenting as necessary:

a) identify the nature and quantities of wastes in the Port Hope area and other sources of wastes in the province;

b) identify the most promising available technologies for low level radioactive waste disposal and indicate the constraints relative to each one;

c) for various geological settings within the province, identify which of the above technologies are most suitable;

d) for each technology which can be used in Ontario, identify the associated economics, including estimates of the capital cost of construction and operation, as well as employment opportunities; and,

e) for each region of the province, identify the cost of transporting wastes by whatever modes are reasonably available from the Port Hope area to a hypothetical disposal facility in that region. In

addition, analyze the health, safety and environmental risks for each transportation option.

Members of the Task Force

In searching for appropriate candidates to serve on the Task Force, Energy, Mines and Resources Canada emphasized the fields of medicine, social impact assessment, land use planning, industrial development, forestry/agriculture, municipal government, environmental sciences and technology.

Various agencies and groups advising on the establishment of the Task Force recommended individuals with broad general knowledge and specialized experience in these areas. Every effort was made to find individuals who would be objective and nonpartisan.

Over twenty individuals were identified and, through a process that included interviews, this number was reduced to seven, including one from the Port Hope area. Six are private citizens and one is a government official, who will serve as the coordinator of the Task Force.

Audrey Armour

An assistant professor in the Faculty of Environmental Studies at York University, Ms. Armour has extensive experience with environmental and social impact assessment. She has excellent communication skills and has served in important public consultation roles in the field of issue resolution. Recently, she has been involved in assessing the implications and responses to the "not in my back yard" syndrome. She is currently involved in providing advice to, among others, the Ontario Waste Management Corporation. She has considerable interest in the development of such a process as is proposed for the siting of low level radioactive waste disposal facilities.

Dr. Michael Chamberlain

Dr. Chamberlain is the Chief of Nuclear Medicine at the University Hospital in London, Ontario, and is also a professor and Chairman of the Division of Nuclear Medicine for the University of Western Ontario. He has extensive experience in the nuclear medicine field and has served as chairman on many organizations related to his field of work. An excellent communicator, he has a

considerable personal interest in helping people to better understand and appreciate the true consequences of radiation exposure. He has served as an expert advisor in public hearings and is experienced with the natural reactions that many people harbour toward radiation.

Gerard Gervais

Mr. Gervais is currently a principal in the Maxion Corporation with direct responsibility to assist industry and municipalities with advice and support on real estate and economic development issues. His education is in environmental studies and business administration. He has considerable experience in dealing with regional planning and development within the Province of Ontario through previous employment which included a two year stint as the Commissioner of Economic Development for the Regional Municipality of Durham. An excellent communicator, he has learned how to present development opportunities in an objective manner. He has an interest in this particular issue because of its potential as a model for the siting of other types of disposal facilities.

Marilyn McHolm

Mrs. McHolm is a real estate agent in the Port Hope area. She has served for over ten years as an elected councillor within Hope Township. During that time, she has sat on, or chaired, most of the municipal committees in the Township. She has a proven record in municipal politics and a thorough understanding of how municipal government systems operate. She is also knowledgeable in the agricultural area as she and her husband operate a dairy farm in the area. Having grown up in the Port Hope area, she is very much aware of the low level radioactive waste issue, and has served on environmental committees addressing previous Eldorado activities.

Dr. James McTaggart-Cowan

Currently the Director of the Office of Environmental Affairs at Energy, Mines and Resources Canada, Dr. McTaggart-Cowan is the sole public servant on the Task Force and will serve as the coordinator. He has a long work history as a research scientist with specialized expertise in environmental issues. The Office of Environmental Affairs will also serve a support function as a Secretariat for the Task Force.

Dr. Arthur Porter

Professor Emeritus of industrial engineering at the University of Toronto, Dr. Porter was recently the chairman of the Ontario Royal Commission on Electric Power Planning. He has a distinguished academic and professional career spanning over 50 years and has developed an extensive knowledge of the nuclear field. Among his numerous and varied experiences, he served as the Chairman of the Canadian Environmental Advisory Council to the federal Minister of the Environment for three years in the early 1970s.

Paul Rennick

Currently a senior Environmental Management Consultant in Burlington, Mr. Rennick's education is in forestry, regional planning and resource development. He has served in a number of private and public sector positions, including a period as the Director of the Environmental Assessment Branch, Ontario Ministry of the Environment. He has extensive knowledge of provincial and private sector operations and has demonstrated excellent communication skills. He has served as editor of the former Ontario Tree Farmer Magazine of the Ontario Forestry Association and is currently involved with environmental protection and integrated environmental management issues as they relate to regional planning and development. He has an excellent knowledge of forestry issues in Ontario, and a personal interest in finding a resolution to the siting problems associated with disposal facilities.

- 30 -

Appendix D

Radiation, radioactivity and health

Appendix D
Radioactivity, radiation and health

A dictionary definition of radioactivity reads: **"Spontaneous disintegration of unstable atomic nuclei . . . accompanied by emission of charged particles and gamma rays."**[31]

Thus, radioactive substances are composed of atoms of which the nuclei are unstable, i.e., which spontaneously decay emitting energy in the form of heat, alpha particles, beta particles and/or gamma rays. Radioactive decay continues until a stable atomic structure is achieved; this frequently means that a radioactive nucleus will undergo a series of transformations before radioactivity ceases.

All atoms with nuclei containing the same number of protons have identical chemical properties and are called isotopes of the element in question. Isotopes may be radioactive or stable. Thus, some radionuclides share their chemical properties with stable isotopes. An example of this is carbon, which has 7 different forms, or isotopes. Two of these isotopes – Carbon 12, Carbon 13 – are stable, i.e., non-radioactive, while five of them – Carbon 10, Carbon 11, Carbon 14, Carbon 15, Carbon 16 – are radioactive and are referred to as radioisotopes. Some elements, such as uranium, have a large number of isotopes, none of which is stable. This chemical similarity plays an important role as it allows the isotopes to react in the environment in a similar fashion, while retaining their radioactive individuality. Each radionuclide, including radioisotopes of the same element, has unique radioactive characteristics, such as the amount and form of energy it emits and its rate of decay (half-life).

Alpha particles are positively charged, comparatively heavy particles made up of two protons and two neutrons. Because of their size, alpha particles have little penetrating power and can be stopped by a sheet of paper or a layer or two of skin. However, if an alpha-emitting substance is inhaled or swallowed, it can do more damage than other radiation because of the mass and charge of the alpha particles.

Beta particles are high-velocity electrons (negatively charged) or positrons (positively charged). They are about one ten-thousandth the mass of an alpha particle and consequently can penetrate tissue and material more readily; an average energy beta particle can penetrate about one centimetre of tissue or water. However, to do damage, beta-emitting material must be ingested or be in direct contact with the body surface. The damage then caused to chromosomal material is less that caused by alpha radiation because the total energy released is spread over a longer path.

Gamma rays are high-energy electromagnetic waves which are considerably more penetrating than beta particles. Their penetration power covers a wide range. At their highest energy level, they can penetrate almost a metre of concrete and several centimetres of lead, while at their lowest energy level, thin glass can stop them. They are able to do harm to cell structure at a distance; however, the dose of radiation received falls off rapidly as the distance from the source increases.

Ionizing radiation

Alpha and beta particles and gamma rays are three forms of the particular type of radiation known as ionizing radiation. This radiation, as discussed in Chapter two, can cause changes in the atomic structure of whatever it strikes because of its ability to form ions. X-rays – whether produced naturally by the sun or other stars, or produced artificially in radiographic machines – and cosmic rays from interstellar space are also classed as ionizing radiation.

Ionizing radiation is an inescapable feature of the global environment and has been present since before the existence of life on earth. As such, it is perhaps more reasonable to regard it as a necessary condition for life, rather than just as a hazard to life. In fact, natural radiation is one of the causes of the mutations which, with the assistance of natural selection, have allowed the occurrence of evolution.

Humans receive natural ionizing radiation from three main sources:

- Many natural rocks, minerals and soils contain small proportions of radionuclides which result in human exposure, particularly when these materials are used in construction. This source includes the naturally occurring radioactive gas radon, which is discussed in more detail later.
- Humans are irradiated from within their own bodies which contain naturally occurring radioactive elements. This characteristic is shared with all living matter. Ingesting any plant or animal foodstuff will add to the amount of radioactive material incorporated into the body. Because humans are themselves radioactive, they are constantly irradiating each other and their environment, to a minor extent.
- Cosmic rays, chiefly in the form of neutrons, impinge upon the earth and both directly irradiate humans and create further amounts of radioactive material such as Tritium. The concentration of cosmic rays varies with latitude and altitude, but nowhere are they escapable.

Biological effects of ionizing radiation

Ionizing radiation can cause biological changes when it interacts with living tissue. For such an interaction to occur, the ionizing radiation must score a "hit" on the tissue. At low radiation doses, the most frequently encountered effects occurring as a result of damage to DNA (chromosomal material) are:

- an increased prevalence of fatal and non-fatal cancers;
- an increased prevalence of birth defects; and
- an increased prevalence of genetic abnormalities (mutations) which may be transmitted to subsequent generations when they occur in germ cells of individuals with reproductive potential.

The three effects listed above are all or none. That is, they are either present or not present in a given individual. As an individual's exposure to ionizing radiation increases, so the likelihood that he or she will suffer the effect in question increases. Similarly, as the size of the population exposed to a given level of ionizing radiation increases, so the number of individuals exhibiting the effect increases. The development of skin cancer in some individuals exposed to the ultraviolet rays of sunlight is an example of this phenomenon, whereas the development of sunburn is not: above a certain exposure (threshold), every individual exposed will burn and the severity of the burn will increase with increasing exposure.

It is also characteristic of the three effects under discussion that, at the upper end of the scale, there is no radiation exposure so high it will guarantee that every exposed individual will suffer the effect. Nor at the lower end is any exposure so low that it will carry no risk to anyone of inducing the effect. These radiation effects are therefore said to have "no threshold." Logically, it follows that any exposure to radiation, no matter how small, carries some risk and that any reduction in exposure, even from an already very low level, confers some benefit. However, it is not always appreciated that the absence of a "safe" threshold is a theoretical assumption and a safety precaution rather than something that can be proven. It is also not well understood that the toxic effects of radiation, for which there is no defined safe level, may not differ fundamentally from those of some chemical toxins for which a "safe" level in the body or in the environment has been declared.

All three of the effects under discussion have high rates of spontaneous occurrence in populations not exposed to ionizing radiation other than naturally occurring background radiation. It is known that specific toxins or chemicals are responsible for damage to chromosomal material and hence for causing genetic mutations, birth defects and cancer induction. Indeed, many such toxins other than radiation are identified and, like ionizing radiation, a few are valuable in the treatment of cancer (e.g., chemotherapy). However, for the foreseeable future, the overwhelming majority of mutations, birth defects and cancers will continue to be regarded as arising "spontaneously."

At the time of birth, each of us faces an approximate one in six risk of dying of cancer. The likelihood increases as we avoid accidents and infections, and we progress from childhood to adult life.

The spontaneous prevalence of birth defects is usually quoted at three to six percent of births, depending on what criteria are used for defining a defect.

Genetic abnormalities may be demonstrated in approximately 10 percent of all live births.

At low levels of exposure to ionizing radiation, the increased prevalence of any of the effects is very small in relation to the number of cases occurring spontaneously. As a result, it may be extremely difficult, and is often impossible, to prove or disprove with statistical validity that a given effect is present in a population. The problem is compounded by the fact that a radiation-induced cancer, genetic abnormality or birth defect is totally indistinguishable from one which occurs spontaneously or in response to some cytotic (toxic to cell nucleus) chemical, or other carcinogens such as those contained in tobacco smoke. Thus, it is never possible to say whether one individual's cancer or birth defect is due to radiation exposure, even when there is proof that significant exposure has been received. It may be possible to prove that the prevalence of cancer or birth defects in a particular population is elevated relative to a control population and to relate this to radiation exposure. However, the logistics of performing a valid epidemiological study are often overwhelming.

The problems with health surveys

A question frequently asked is whether the incidence of cancer or birth defects in a particular population is higher than normal or "higher than it should be." This may be because of the observations or perceptions of lay individuals or health professionals that an unexpected cluster of abnormalities has occurred. Alternatively, a survey may be requested by concerned individuals or groups who fear, or have reason to believe, that the population has been excessively exposed to radiation or to some chemical which has cytotoxic or chromosomal effects.

The idea of carrying out a survey is entirely reasonable because the astute observations of lay or professional individuals have often led to the discovery of previously unrecognized dangers and associations. The value of epidemiological techniques is accepted as a standard scientific tool, hallowed in the history of public health. Unfortunately, the recognition that a tool or technique is powerful may lead to unreasonable or overly optimistic expectations, with failure to appreciate the limitations of that power. The lay individual, having been dazzled by the remarkable ability of a computer in one particular application, may be persuaded that the machine can do almost anything. Disillusion and resentment are likely to follow when reality is discovered to lag so far behind hope. Epidemiology is particularly prone to engender hope and suffer resentment when its inherent limitations are realized. It may rapidly be condemned as a remote, theoretical and unhelpful science or even the tool of an uncaring establishment when its inability to help individuals or particular communities is exposed.

It is generally accepted that an individual absorbing a dose of ionizing radiation measuring 10 milliSieverts is subject to a 1 in 10,000 added risk of dying from cancer. (The dose of 10 mSv is very large in relation to the likely yearly dose absorbed by individuals in a population exposed to low-level radioactive wastes.) The determined pre-existing risk to an adult of dying of cancer is in the order of 1 in 5. Hence, the additional radiation exposure from an increment of 10 mSv will increase the pre-existing risk by 0.0005 percent. The difficulty in detecting such a small effect is compounded by the fact that there is a latent period between radiation exposure and the occurrence of a radiation-induced cancer of 7 to 40 years. Natural background radiation may vary substantially from neighbour to neighbour, when inhalation of naturally occurring radon is taken into account. Additionally, there is the complicating factor of exposure of certain individuals to ionizing radiation for medical diagnostic purposes in doses which are relatively high in relation to those received from low-level radioactive wastes. All of this means that, to have a reasonable expectation of proving or disproving the presence of an excess of cancer of the order likely to result from exposure to low-level radioactive wastes, a study would have to be extended to a population

at risk of millions and would require an appropriate control population of similar magnitude and a period of years to complete. Leaving aside the question of cost, it can be seen that the logistics are such that a definitive study is extremely unlikely ever to be undertaken, if only because reasonably homogeneous populations at risk may range from a handful of individuals to, at most, a few thousand in relation to a particular accumulation of low-level radioactive wastes.

It remains only too easy to understand how requests for health surveys will continue to arise and how surveys, which are doomed to inconclusiveness before they start, will be undertaken with varying degrees of insight and cynicism by those who conduct or request them. Some officials will find it impossible to resist a survey, lest they appear uncaring and unresponsive to genuine concerns in a community; some people are in the business of surveys; and some will be pleased to use the somewhat flawed evidence of an imperfect study to bolster their prejudice. This latter behaviour is a very common human trait, from which scientists are by no means immune.

In light of the difficulties referred to, and the entirely proper ethical constraints on experimental work involving humans, the great majority of knowledge concerning radiation effects and the assessment of risks to humans must be derived by extrapolation from other species and from relatively high doses compared to the actual doses most commonly received. This comment is not to discredit such actual knowledge. On the contrary, the relative lack of constraint on an experimental study may make data derived from it greatly preferable to a necessarily imperfect human study. Extrapolation may be done in such a way as to build in safety margins and guard against worst-case scenarios. However, the inherent limitations of extrapolations must always be kept in mind.

Naturally occurring radioactive substances

Of more than 1800 identified radionuclides, those of uranium (especially the radioisotopes Uranium 238 and Uranium 235) are the most widely used. These isotopes are the precursors (i.e., parents) of whole chains of radionuclides, as shown in Table A. Uranium 235 is the key to the nuclear power industry. It is not surprising, therefore, that uranium and the radioactive substances to which it gives rise feature centrally in all radioactive waste considerations.

Table A

Uranium and Thorium radioactive decay series

Uranium 238	**Uranium 235**	**Thorium 232**
Uranium 238	Uranium 235	Thorium 232
Thorium 234	Thorium 231	Radium 228
Protactinium 234	Protactinium 231	Actinium 228
Uranium 234	Actinium 227	Thorium 228
Thorium 230	Thorium 227	Radium 224
Radium 226	Radium 223	Radon 220
Radon 222	Radon 219	Polonium 216
Polonium 218	Polonium 215	Lead 212
Lead 214	Lead 211	Bismuth 212
Bismuth 214	Bismuth 211	Polonium 212 Thalium 208
Polonium 214 Thalium 210	Polonium 211 Thalium 207	Lead 208 (stable)
Lead 210	Lead 207 (stable)	
Bismuth 210		
Polonium 210		
Thalium 206		
Lead 206 (stable)		

Source: A.T. Gable and D.K. Baker, *Elements of Modern Physics*, New York: Ronald Press Company, 1962, pp. 341-342.

Since the earth was formed, rock formations have emitted natural radiation. Granitic rocks, in particular, contain elements of uranium and thorium. In fact, these ores are more than a thousand times more abundant in the earth's crust than gold and about four times more abundant than tin. Uranium concentrations vary greatly in the earth's crust. In some cases, highly concentrated ore bodies can be found. An example of this is the recently discovered fact that as many as six completely natural nuclear reactors "operated" for 200,000 years in the vicinity of Oklo, Gabon, about two billion years ago. This phenomenon occurred in natural uranium ore bodies when fresh water seeped into the rocks containing the uranium, thus producing "light water reactors" operating in the same fashion as most of the man made reactors in use today. It is interesting to note that, according to one authority, "The escape of radioactive products from the Oklo reactor zone was quite limited."[32] This is significant as it proves that neither the invention of the nuclear fission reactor nor the creation of Plutonium (a key component of nuclear weapons) were inventions of humans – they were inventions of nature: humans have merely developed a means of controlling and containing this natural process.

Fluids or gases emitted from the earth may contain significant amounts of the radioactive gas radon (a particularly potent radiation risk as will be explained shortly). The burning of all fuels in the home releases radon and raises, albeit slightly, the background radiation level. Groundwater also contains radon. For example, it has been estimated by the U.S. Environmental Protection Agency that between one third and one half of all groundwater supplies have radon concentrations greater than 18 Becquerels per litre.

Another radionuclide which occurs widely at very low concentrations is the heaviest isotope of hydrogen, called Tritium (Hydrogen 3) with a half-life of 12.26 years. It emits beta particles and decays into Helium 3. It is constantly being produced in the upper atmosphere and in all lakes, rivers, and oceans by the capture of cosmic rays by atoms of Deuterium (Hydrogen 2), a naturally occurring isotope of hydrogen.

Although there are many other naturally occurring radioactive substances, uranium and thorium are the dominant elements in discussions about low-level radioactive wastes. They are the "parents" of the "decay chains" of radionuclides (as shown in Table A) which include the extremely important and, in some respects, dominant "offspring," radium and one of its "daughter" products, radon. Because of its often unsuspected presence in our immediate environment, radon merits special attention.

Radon

As uranium and thorium occur naturally everywhere on earth in concentrations which vary greatly from place to place, so too does radon. It is primarily found as three different isotopes – Radon 222, Radon 220, Radon 219. Since it is a chemically inert but soluble gas, radon can diffuse through the ground and later emerge far from its source. Because of the variation in its concentration, even within a single neighbourhood, radon and its decay products may be the major contributors to natural background radiation, in some places as high as 50 percent, while in other places, they are insignificant. It is worth noting that radon is frequently not reported as part of background radiation levels because of its extreme variability.

The danger presented by radon is a complex and multifaceted problem because radon, itself radioactive, serves as a parent for a series of similarly radioactive daughter products. Alpha particles are emitted by the radon parent and many of its daughters. Thus, if radon is inhaled, the bronchial mucosa of the lungs is directly exposed to the decay particles; this may provoke or, in the case of smokers, assist in provoking the development of lung cancer. Radon gas, if it is in a confined space such as a building with poor ventilation, gradually comes into equilibrium with its daughters resulting in a high concentration of alpha emitters. Radon, given off into a well-ventilated space or in the open air, however, is rapidly dispersed, does not enter into equilibrium with its daughters and therefore poses less hazard. Thus, we have the complicated situation whereby the hazard posed by a given concentration of radon and the accompanying concentrations of its daughters varies according to the ventilation of the place where they are released. Complicating the situation even further is the fact that the radon daughters can become attached to non-radioactive dust particles in the air, as a result of electrostatic forces, and can also be inhaled and deposited on the bronchial mucosa. Thus, the toxicity of a given concentration of radon differs, not only according to the ventilation of the place where it is released, but also according to the concentration and type of dust in the air and the pattern of breathing of the exposed individual.

As uranium and thorium are components of many of the accumulations of low-level radioactive wastes, radon may be a major constituent of whatever threat to human health or the environment such wastes pose.

Appendix E

Glossary of terms

Appendix E
Glossary of terms

Actinide:
A group name for the series of radioactive elements from element 89 (Actinium) through 103 (Lawrencium) – it includes thorium, uranium, and plutonium.

Adsorption:
The adsorption of radioactive waste relates to the capability of soils, clay, etc., to retain the material and hence prevent it from reaching the biosphere; "adsorption coefficient" is a measure of the effectiveness of, for example, a backfill material.

AECB:
Atomic Energy Control Board

AECL:
Atomic Energy of Canada Limited

ALARA:
Acronym for "as low as reasonably achievable," the principle generally accepted in radiation protection that radiation exposures and releases of radioactive materials should be as low as reasonably achievable, taking social and economic factors into account.

Alpha particle:
A heavy particle produced by a radioactive decay process. It consists of two protons and two neutrons and is identical with the nucleus of a helium atom.

Atom:
The building block of nature, an atom is composed of a nucleus containing protons and neutrons surrounded by orbiting electrons.

Atomic mass:
The mean mass of the atoms of an element measured relative to the mass of the nuclide Carbon 12.

Backfill material:
Material put in place to fill in voids between containers and thus to curtail the transport of radionuclides from a waste storage facility. Common materials are mixtures of sand and clay (bentonite, kaolin and illite).

Background radiation:
The natural ionizing radiation from such sources as cosmic rays from outer space, naturally occurring radioactive elements in the ground and naturally occurring radioactive elements in a person's body.

Becquerel:
A measure of the amount of radioactivity. A Becquerel is defined as one nuclear disintegration per second.

Beta particle:
A light particle produced in radioactive decay processes. It may carry a positive or a negative charge and is identical to an electron in mass.

BNPD:
Bruce Nuclear Power Development.

CANDU:
Acronym for Canadian Deuterium-Uranium Reactor

Community Liaison Group:
An independent group of citizens set up by the Siting Task Force in negotiation with municipal councils to facilitate the participation and input of local residents in the siting process, thereby ensuring full representation of a broad range of community interests.

Community relations measure:
A policy, program or administrative procedure which aims to maintain, throughout the life of a facility, including its post-closure phase, a cooperative, non-adversarial relationship between the facility owners and operators, and the local community.

Compensation measure:
A policy or program which aims to offset the unavoidable negative effects of a proposed development and thereby enhance local benefits.

Contingency measure:
A policy, program or operational practice which aims to aid in the detection and timely response to potential problems and unanticipated effects.

Cosmic rays:
Consist of neutrons, protons, gamma radiation and other fundamental particles which emanate from the sun and outer space and impinge on the earth. Their effect is greatest at high altitude and towards the poles.

CRNL:
Chalk River Nuclear Laboratories

Decay chain:
A succession of radionuclides, each one formed by the decay of the previous one. In a radioactive decay chain the decaying nuclide is termed the "mother" radionuclide and the nuclide it decays to is termed the "daughter" nuclide.

Disposal:
A method of dealing with radioactive waste for which there is no intention of retrieval or long-term monitoring.

DNA:
Acronym for deoxyribonucleic acid which is found in the nuclei of cells. It is the principal constituent of chromosomes, the structures that transmit hereditary characteristics.

Dose:
A general term denoting the quantity of energy absorbed from radiation. For specific use it must be qualified (e.g., absorbed dose).

EARP:
Acronym for the federal Environmental Assessment and Review Process

EMR:
Energy, Mines and Resources Canada

Engineered barrier:
Man-made barriers (in contrast to natural barriers) to the movement of radionuclides such as plastics and concrete.

Fission:
The splitting of a heavy atomic nucleus into two (or more) parts, accompanied by a release of energy.

Fission product:
A nucleus of intermediate size formed as a result of the fission of a heavy nucleus such as that of uranium.

Gamma rays:
Electromagnetic radiation of relatively high frequency emitted from the nuclei of a radionuclide in the process of radioactive decay.

Genetic effects:
Damage to genes resulting in mutations as a result of toxic effects on chromosomes. These may be significant if they occur in germ cells or their predecessors in individuals with reproductive potential because they may be passed on to the next generation where mutations may be manifested in stillbirths, congenital defects or a variety of effects usually, but not necessarily, deleterious.

Half-life:
The time in which one half of the original number of nuclei of a particular radionuclide will have undergone radioactive decay.

High-level waste:
Radioactive waste that initially requires continuous active cooling in order to dissipate the internally generated heat. In Canada, the only waste categorized as high-level is CANDU spent fuel.

ICRP:
International Commission on Radiological Protection, a group formed in 1928 with the function of recommending international standards for radiation protection.

Impact management:
A strategy of environmental protection that involves the application of compensation, mitigation, contingency and community relations measures identified as necessary through detailed impact assessment studies.

Ion:
An atom that has gained or lost one or more electrons and which thus becomes electrically charged.

Ionizing radiation:
Radiation which can deliver energy to matter in a form capable of creating ions.

Isotope:
Different forms of a single element having identical chemical properties but different masses. Nuclei contain identical numbers of protons but different numbers of neutrons.

Low-level radioactive waste:
All those radioactive wastes, other than spent fuel, arising from the mining, milling, refining or use of materials containing radionuclides.

Mitigation measure:
A facility or site design feature, construction practice, or operational procedure which aims to prevent or minimize any potentially negative effects of a proposed development.

Neutron:
Electrically neutral particle of about the same mass as a proton. Atomic nuclei consist of an assembly of neutrons and protons tightly bound together.

NIMBY:
Acronym for "not-in-my-backyard" and a label often used to describe the negative response of residents to proposals for siting hazardous and other unwanted facilities in their communities.

Nuclear energy:
The energy liberated by a nuclear reaction. In large scale nuclear reactors it is created by the fissioning of nuclei of Uranium 235.

Nuclide:
A species of atom distinguished by the constitution of its nucleus, i.e., the number of protons, the number of neutrons and the energy content.

OH:
Ontario Hydro

Poll:
A sampling or collection of opinions on any matter or issue.

Radioactivity:
Process in which nuclei spontaneously undergo decay and emit radiation.

Radionuclide:
A species of atom which has a nucleus with the potential for radioactive decay.

Regional profile:
A descriptive account of key environmental, social and economic characteristics of a regional planning district.

Risk assessment:
A scientific analysis of the probability of occurrence and consequence of potential hazards associated with a particular event.

Risk perception:
A subjective or intuitive assessment of the hazards associated with a particular event.

Scoping:
An exercise of identification and ranking of the key issues associated with a proposed undertaking.

Special impacts:
Impacts resulting from the stress and stigma often accompanying projects that are regarded as hazardous or, for some other reason, locally unwanted.

Standard impacts:
Impacts generally associated with any development activity and encompassing economic, demographic, housing, fiscal, public services and social impacts.

Tailings:
Material rejected after ore is processed.

Transuranic waste:
Waste contaminated with alpha-emitting radionuclides of atomic mass greater than 238. Such waste only occurs as part of low-level radioactive wastes (albeit in extremely small amounts) as a result of a minor failure of fuel containment in the operation of a CANDU reactor. For practical purposes in Canada, its contribution to low-level radioactive waste is negligible. The same situation does not apply in the United States.

Tritium:
A radioactive isotope of hydrogen in which the nucleus contains one proton and two neutrons (i.e., Hydrogen 3).

Appendix F

Task Force letter to DOE, MOE, NH&W, and AECB

SITING PROCESS
TASK FORCE
low level radioactive waste disposal

GROUPE DE TRAVAIL :
PROCESSUS DE LOCALISATION
élimination des déchets faiblement radioactifs

May 19, 1987

Mr. P.M. Higgins
Director General
Environmental Protection Directorate
Environment Canada
Place Vincent Massey
351 St. Joseph Blvd.
Hull, Quebec
K1A 0E7

Dear Mr. Higgins:

As you know, a federal Siting Process Task Force on Low-Level Radioactive Waste (LLRW) Disposal was set up in December, 1986, by the Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines). It was charged to devise a process for the siting of a facility for LLRW disposal and transportation. Attached please find the press releases issued concerning the Task Force and its mandate.

As part of our work, we have commissioned an inventory of LLRW. The resulting document, which is also attached, was produced by the Atomic Energy of Canada Limited entitled, "Inventory of Waste Quantities". The inventory includes what has traditionally been referred to as historic wastes (both federal and provincial), incidental wastes, nuclear energy and radioisotope wastes, and uranium mine tailings as all are considered to be low-level radioactive wastes.

The Task Force requires an authoritative statement concerning the threat to human health and to the environment posed by each particular accumulation of LLRW in each category in the inventory. This is needed in order to recommend a logical strategy for their management. We are aware that there is often a disparity between scientifically measured risk and perceived risk. We are also aware that in the case of some radioactive wastes, the most serious health or environmental threat comes not from the radioactivity but from associated substances such as arsenic or heavy metals.

Given the above situation, we would very much appreciate it if you would assist us by preparing, in the most precise numerical terms possible, your assessment of the risks to human health and to the environment at each of the sites of LLRW accumulation. It would be helpful to know the basis for the risk assessments and the assumptions which underlie them, eg. rates of leaching, population at risk, time scale, etc. It would also be helpful to have some standards of comparison for similar risks and, where they

538-580 BOOTH, OTTAWA, ONTARIO, K1A 0E4 (613) 995-8607/995-3866

exist, the acceptable limits or action levels which indicate the imperative for containment, storage, or disposal. Where radioactive materials are associated with other toxic substances, we would like to see an identification of the one which poses the greatest threat and, therefore, whose control should determine the urgency and the technique of necessary action.

I am certain that you will appreciate the need for our recommendations to be soundly-based. We understand that the existence of the various accumulations of LLRW is already well known to you. It is the intention of the Task Force to publish not only its report but also certain supporting documents, since an open approach is essential in creating trust in the process. Therefore, you should be aware that your response to us is likely to become public. However, we would respect your wishes should you wish to make confidential any commentary upon your report which you feel would be helpful to our understanding of it. As work must be completed by this summer, a response by June 17 would be greatly appreciated.

We have written similar letters to AECB and H&WC in view of their responsibilities in this field.

Yours sincerely,

J.D. McTaggart-Cowan
Coordinator
Siting Process Task Force

Enclosure

SITING PROCESS
TASK FORCE
low level radioactive waste disposal

GROUPE DE TRAVAIL :
PROCESSUS DE LOCALISATION
élimination des déchets faiblement radioactifs

June 4, 1987

Mr. Dave Balsille
Assistant Deputy Minister
Environmental Services Division
Ministry of Environment
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Dear Mr. Balsille:

As you may know, a federal Siting Process Task Force on Low-Level Radioactive Waste (LLRW) Disposal was set up in December, 1986, by the Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines). It was tasked with devising a process for the siting of a facility for LLRW disposal. Attached please find the press releases issued concerning the Task Force and its mandate.

As part of our work, we have commissioned an inventory of LLRW. The resulting document, which is also attached, was produced by the Atomic Energy of Canada Limited entitled, "Inventory of Waste Quantities". The inventory includes what has traditionally been referred to as historic wastes (both federal and provincial), incidental wastes, nuclear energy and radioisotope wastes, and uranium mine tailings as all are considered to be low-level radioactive wastes.

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We have written similar letters to the Federal Departments of National Health and Welfare and Environment, as well as the Atomic Energy Control Board, in view of their responsibilities in this field.

If you have any questions regarding this request, please do not hesitate to contact me at (613) 992-9924.

Yours sincerely,

J.D. McTaggart-Cowan
Coordinator
Siting Process Task Force

Enclosure

SITING PROCESS
TASK FORCE
low level radioactive waste disposal

GROUPE DE TRAVAIL :
PROCESSUS DE LOCALISATION
élimination des déchets faiblement radioactifs

May 19, 1987

Dr. E. Somers
Director General
Environmental Health Directorate
Health & Welfare Canada
Environmental Health Centre
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

Dear Dr. Somers:

As you know, a federal Siting Process Task Force on Low-Level Radioactive Waste (LLRW) Disposal was set up in December, 1986, by the Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines). It was charged to devise a process for the siting of a facility for LLRW disposal and transportation. Attached please find the press releases issued concerning the Task Force and its mandate.

As part of our work, we have commissioned an inventory of LLRW. Attached is the document produced by the Atomic Energy of Canada Limited entitled, "Inventory of Waste Quantities". The inventory includes historic wastes (both federal and provincial), incidental wastes, nuclear energy and radioisotope wastes, and uranium mine tailings since all are considered to fall within the mandate of the Task Force.

The Task Force requires an authoritative statement concerning the threat to human health and to the environment posed by each particular accumulation of LLRW in each category in the inventory. This is needed in order to recommend a logical strategy for their management. We are aware that there is often a disparity between scientifically measured risk and perceived risk. We are also aware that in the case of some radioactive wastes, the most serious health or environmental threat comes not from the radioactivity but from associated substances such as arsenic or heavy metals.

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We have written similar letters to AECB and DOE in view of their responsibilities in this field.

Yours sincerely,

J.D. McTaggart-Cowan
Coordinator
Siting Process Task Force

Enclosure

SITING PROCESS
TASK FORCE
low level radioactive waste disposal

GROUPE DE TRAVAIL :
PROCESSUS DE LOCALISATION
élimination des déchets faiblement radioactifs

May 19, 1987

Mr. W.D. Smythe
Director General
Directorate of Fuel Cycle
and Materials Regulations
Atomic Energy Control Board
Martel Bldg.
270 Albert Street
Ottawa, Ontario
K1P 5S9

Dear Mr. Smythe:

As you know, a federal Siting Process Task Force on Low-Level Radioactive Waste (LLRW) Disposal was set up in December, 1986, by the Honourable Gerald S. Merrithew, Minister of State (Forestry and Mines). It was charged to devise a process for the siting of a facility for LLRW disposal and transportation. Attached please find the press releases issued concerning the Task Force and its mandate.

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Yours sincerely,

J.D. McTaggart-Cowan
Coordinator
Siting Process Task Force

Enclosure

Appendix G

Response to Task Force letter

Environment Canada | Environnement Canada
Regional Director General | Directeur général régional
Ontario Region | Région de l'Ontario

25 St. Clair Avenue East
Toronto, Ontario
M4T 1M2

Telephone: (416) 966-6406

Our File: 1165-36/A42-21

Your File:

June 26, 1987

Dr. J.D. McTaggart-Cowan
Coordinator, Siting Process T F
580 Booth Street
Ottawa, Ontario
K1A 0E4

Dear Dr. McTaggart-Cowan:

Thank you for providing us with the document "Inventory of Waste Quantities" prepared for the Siting Process Task Force.

We have received this document and are providing you with some comments regarding approaches taken to assess the nature of hazardous waste in general and environmental considerations related to the low level radioactive waste sites specifically.

I have also attached for your information a copy of the recently released Canadian Water Quality Guidelines & Status Report to IJC on the Remedial Action Plan for Port Hope harbour.

Yours truly,

for E. Dowdeswell
Regional Director General

cc. R. Krauel

ED/bb
546

Inventory of Waste Quantities
Siting Process Task Force

This document will discuss the nature of various waste identified in the document entitled "Inventory of Waste Quantities" prepared for the Siting Process Task Force. In addressing the environmental threats posed by the wastes we will present approaches used by our department in defining the hazards of wastes in general and criteria which are applicable in site specific cases. While a detailed quantification of environmental risks would require further information we can discuss various factors associated with each waste which contribute to environmental impact and comparisons can be made in qualitative manner.

Our primary role concerning these wastes is associated with our advisory function in the AECB joint regulatory process or with other federal agencies. We have not addressed incidental waste as they are not regulated under this process nor are they considered under the mandate of the Low Level Waste Management Office.

Defining the Hazards of Waste

The term "hazardous waste" has been defined by CCREM as "those wastes which due to their nature and quantity are potentially hazardous to human health and or the environment and require special disposal techniques to eliminate or reduce the hazard".

In defining the nature of the hazard of a waste one must consider the characteristics of the waste itself, the facilities in which the waste has been placed and the sensitivity of the surrounding environment.

The first step is usually to consider the characteristics of the waste. Regulations (eg. TDGA, Ontario Reg. 309) generally employ two approaches to defining a hazardous waste; 1) listing and 2) testing. Lists of hazardous substances can be developed using criteria such as;

- chronic toxicity (carcinogenic, teratogenic, genotoxic)
- aquatic toxicity
- bioaccumulation
- persistence in the environment

Testing generally employs the use of leachate extraction procedures to determine the potential of a waste to generate leachate containing concentrations of contaminants which may have an adverse impact as they move through the environment. Leachate characteristics are often compared to established criteria to define whether it is hazardous or not. Under Ontario Regulation 309 a waste is defined as hazardous if the leachate of a waste contains contaminants that exceed ten times the Ontario Drinking Water Criteria.

Site Specific Hazard Assessment

Assessing the hazard of a site depends on source - pathway - receptor evaluation.

The source must first be defined in terms of chemistry and quantity of contaminated liquid effluent (leachate) or air emission produced.

The pathways through which the contaminants move in the environment and their impact on the environment must be assessed considering the ability of the disposal facility to contain and the attenuation that occurs as contaminants move

from the site (as the distance from the site increases the level of contaminants usually decreases by natural processes).

In evaluating the impact on the environment one must consider all environmental media (eg. surface water, groundwater, soil, sediments, air) and all environmental receptors (eg. aquatic life, wildlife, vegetation, man etc.). The location of a receptor along the pathway, the contaminant type, concentration, quantity and period of exposure all influence the environmental impact.

Impact assessment generally employs the use of criteria. Current applicable criteria are associated with specific uses (eg. drinking water, protection of aquatic life, use of soil for agricultural purposes etc.). Specific criteria for non radionuclides can be found in documents such as Canadian Water Quality Guidelines - CCREM (1987), or National Air Quality Objectives. Where a parameter of potential significance is not addressed in available guidelines the judgement of acceptable levels should be based on current scientific information.

As criteria are associated with specific uses it is necessary to make assumptions regarding uses of resources in and around a disposal facility. These assumptions must consider both present use and potential future use.

A generalized listing of other factors which should be considered in hazardous waste landfill site selection or assessment is attached.

Environmental Considerations - Low Level Radioactive Waste Sites

Environmental factors associated with the waste management areas identified in the "Inventory of Waste Quantities" are discussed in terms of - nature of waste
- surrounding uses
- site control
- other factors

1) Nature of waste

The general nature of the various waste sources is presented in the inventory. A few additional observations which can be made are;

- Uranium mine and mill tailings and Port Hope - Port Granby area waste are similar in terms of the radiological parameters present (uranium and thorium series radionuclides). Heavy metals are present in both wastes. Arsenic is a particularly important parameter for the Port Hope - Port Granby Waste.

- Uranium tailings present much larger quantities of waste. Elliot Lake tailings representing most of the volume. Elliot Lake tailings are acid generating whereas Bancroft and Espanola tailings have low acid generating potential. Operating Mines (Elliot Lake) also discharge ammonia to the environment.

- BNPD and CRNL wastes are generally similar. There is little information available for either of these sites regarding the presence of chemical contaminants.

2) Surrounding uses

Uranium mining

- forests and a large number of lakes are found in the immediate area of all mines.

- larger population centres (several thousand) are several kilometres away from the mines.

- cabins and cottages used for recreational purposes such as hunting and fishing can be found in close proximity to all areas.

- residences and recreational areas are in closest proximity to the Bancroft mines.

- ammonia discharges from mines in the upper Serpent R. (Elliot Lake) can result in conditions in the area upstream of Quirke lake which are toxic to fish.

Port Hope - Port Granby

- Port Hope waste is located in a population centre.

- Port Hope Harbour sediments may impact on the use of the harbour as a recreational area (yacht club) since sediment cannot be dredged and disposed of. The Ganaraska River which is located adjacent to the harbour area and runs through Port Hope is an important fishing area. Environmental studies (see attached Port Hope Harbour status report) indicate that human consumption of fish should not result in an exceedance of the stochastic dose limit (radionuclides).

- Port Granby and Welcome are both located in agricultural areas. Both areas discharge treated effluent to Lake Ontario. Water is not used for drinking purposes nor is their significant recreational usage in the immediate area of the discharge.

3) Site Control

- Most sites have some form of site control such as restricting access, treatment, maintaining containment structures, monitoring etc. The sites with the least control are the historic sites in the Port Hope area and the abandoned mines in the Bancroft area.

4) Other Factors

- Port Granby is subject to shore erosion processes which will eventually threaten the integrity of the site.

- most sites have generally been addressed in this document in terms of current conditions. It is important to point out that there are also long term considerations. With the exception of the two mines presently under a decommissioning approval other facilities are considered to be storing waste. In order to manage or dispose of the waste for the long term, controls must be maintained or waste must be placed in a manner which requires no controls yet continues to protect the environment. This may be more difficult for the facilities which are dealing with large quantities of waste or have greater reliance on controls such as treatment, maintaining structures, etc.

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July 23, 1987

Dr. J. D. McTaggart-Cowan
Coordinator
Siting Process Task Force
Low Level Radioactive Waste Disposal
538-580 Booth St.
Ottawa, Ont.
K1A 0E4

Dear Dr. McTaggart-Cowan:

Thank you for your letter of June 4, 1987, regarding the report on inventory of LLRW quantities prepared by AECL in May 1987. Staff in the Waste Management Branch of this Ministry have reviewed the report and have provided the attached comments.

Our immediate comments essentially confirm the quantities and levels of low-level radioactive wastes in Ontario. However, we have not been able, within the time available, to provide more detailed information on rates of leaching and population at risk requested in your letter. The comments on public risk refer only to the potential for exposure to radioactivity due to the accessibility of certain sites. Risk assessment is the responsibility of the Minister of Labour.

Since these issues are essentially the responsibility of the federal government, we believe that the Ministry of the Environment can best assist the Task Force by reviewing data made available by AECB and AECL and agencies of the federal government.

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International Year of Shelter for the Homeless
1987
Annee internationale du logement des sans-abri

Please feel free to contact Mr. R. M. Gotts, Director, Waste Management Branch, if the Ministry can be of assistance in reviewing Task Force documents.

Yours very truly,

David Balsillie
Assistant Deputy Minister
Environmental Services Division

Enclosure

COMMENTS ON REPORT ON LLRW INVENTORY OF "WASTE" QUANTITIES

POTENTIAL IMPACT ON ENVIRONMENT AND
THE PUBLIC FROM VARIOUS SITES OF LOW-LEVEL
RADIOACTIVE WASTE (LLRW) ACCUMULATION IN ONTARIO

LLRW accumulations comprise three categories:

I Uranium Mine Tailings;

II Incidental Wastes; and

III Wastes from Nuclear Energy and Radioisotope production and use.

I. URANIUM MINE TAILINGS:

In the Elliot Lake and Espanola areas, the federal government, through the AECB, has licenced the operation or decommissioning of mines. In the Bancroft area, the impact of the Bicroft and Dyno abandoned mines in the area around Paudash Lake is being assessed by the Canadian Institute for Radiation Safety (CAIRS) through a grant from MOE. The Radium 226 (Ra) level in Paudash Lake is below the "Provincial Water Quality Objective" of 1.0 Bq/ℓ. However, the Paudash Lake Conservation Association (PLCA), representing the cottagers in this area, needed an assessment of the radioactive impact on the public and the environment where some water readings were 0.12-0.14 Bq/ℓ which is higher than the "Target Concentration" of Ra in water of 0.1 Bq/ℓ according to Health & Welfare Canada. The PLCA contracted CAIRS to do the assessment.

The impact of the Madawaska and Faraday mines is being assessed by AECB, who licensed their decommissioning, with MOE's advice and assistance. For abandoned tailings, there is no control on public access. Exposure to the public is thus random and unpredictable, clearly a situation that carries with it an increased risk to health.

II. INCIDENTAL WASTES:

° Chromasco Ltd., Haley Station.

60.0 m^3 of slag containing about 2.0% by weight of Thorium 232(Th), were put in drums and placed on two waste piles on Chromasco's property; also 680 m^3 of slightly contaminated soils from the site of this smelting operation were added to the same two waste piles. Residences are at about one km from piles. Access to the site is not strictly controlled suggesting that the public may be exposed unnecessarily to an increased risk.

If there were a site in Ontario where this waste could be disposed of in an approved manner this would allay the public fears of possible health effects in the future due to the proximity of this unplanned waste site at Chromasco.

° Hawker Siddeley Canada Ltd.

Located in an industrial park in the City of Mississauga, this is an AECB licensed, fenced area with 385 drums (75.0 Cu m) of waste metal turnings containing 3.0% Th. Waste is still being generated at a rate of 2.5 Cu/m/year.

Here again, a lengthy process of monitoring and decommissioning, including hearings, could be avoided if there were a site designated for LLRW.

° Masterloy Products Ltd.

This site is located 3.0 km from the South Gloucester community. This is a typical example of doubling or tripling the technical and financial resources to solve a waste management problem. Three waste sites were needed to store this company's waste which could have been easily sent to one main LLRW site in Ontario.

This company has:

1. On its site a pile of 4050.0 m^3 of slag containing Th, Ra and arsenic. Part of it is in drums.

2. Arsenic contamination of soil on site has necessitated some soil stripping ($\sim$ 5000.0 Cu/m) which was disposed of at a municipal landfill site about 15 0 km away.

3. Another property of the same company about 1.0 km away, contained some of the same radioactive waste which was sent to Chalk River. AECB declared that other property as having less than the allowable limits of 100 uR/hr.

° Norton, Exolon & Walker Brothers Quarry Ltd. (WBQL)

This is another example of the urgent need for a LLRW site for all Ontario. The Norton location is near Niagara Falls, not far from a major recreation attraction, viz., Marineland.

There is about 2700.0 m^3 on site at Norton in two metal clad buildings and a concrete silo of dust with levels of U,Th and Ra higher than the feed stock. 6300.0 m^3 of this dust was removed before 1980 to the WBQL landfill site. Also, prior to 1980, 3500.0 m^3 of dust from Exolon were buried in WBQL. On the Exolon property there is still several hundred m^3 of dust buried. There is an estimated population of 1300 within 0.5 km of Exolon.

As a result, there are three unassessed areas for waste storage and disposal rather than one properly designed and approved disposal site.

These are sites without proper control of access suggesting that the public may be unnecessarily exposed to an increased risk.

° IMC (Dunnville) and C-I-L (Sarnia)

Each of these companies has a phosphogypsum tailing site with about 30-50 uR/hr reading at waist height. A few years ago, each of these companies transferred some 'hot' items, like tools and filter cloth, which had a reading of 200-300 uR/hr, to nearby landfill sites - Sherbrooke, near IMC and Walkerport, near C-I-L. Following protests from municipalities and communities, the companies had to take those 'hot' items back onto their properties.

III. WASTE FROM NUCLEAR ENERGY AND RADIOISOTOPES PRODUCTION AND USE:

This is a federal responsibility where AECB, AECL and LLRWMO should be contacted.

However, the Chalk River Nuclear Laboratories (CRNL) waste management site should be mentioned. This site takes in about 60.0% of waste originating from CRNL. It also accepts, for a fee, wastes generated by radioisotopes users across Canada, as well as periodically receiving wastes resulting from cleanup of historic problems.

The problem of soil contamination near McClure Crescent in Scarborough, where radioactive waste deposition resulted from a pre World War II effort to reclaim Ra from luminous paint, could have been mitigated if the CRNL site were easily accessible, or if there were another accessible site for all Ontario.

MINISTRY OF THE ENVIRONMENT
Waste Management Branch
July 1987

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Health and Welfare Canada | Santé et Bien-être social Canada
Health Protection Branch | Direction générale de la protection de la santé

Environmental Health Centre
Tunney's Pasture
OTTAWA, Ontario
K1A 0L2

May 28, 1987

Mr. J.D. McTaggart-Cowan
Coordinator
Siting Process Task Force
538-580 Booth Street
OTTAWA, Ontario
K1A 0E4

Dear Mr. McTaggart-Cowan:

Thank you for your letter of May 19, 1987, asking the Environmental Health Directorate to provide you with an authoritative statement concerning the threat to human health resulting from the operation of various low-level radioactive waste disposal facilities.

I understand that Mrs. D. Meyerhof has been in contact with you by telephone to explain the situation. I regret that we will be unable to provide you with this information. I am afraid that even a qualitative ranking of the different sites would not be possible without many person years of work.

The idea of ranking the sites certainly has merit but the extensive analysis required makes it unlikely that any organization would find it possible to do with existing resources.

Yours sincerely,

E. Somers
Director General
Environmental Health Directorate

Canada

Atomic Energy Control Board | Commission de contrôle de l'énergie atomique

Directorate of Fuel Cycle
and Materials Regulation

Your file / Votre référence

Our file / Notre référence

June 16, 1987

37-5-2-0

Dr. J.D. McTaggart-Cowan
Director
Office of Environmental Affairs
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A OE4

Dear Dr. McTaggart-Cowan:

In your letter of 19 May 1987, you request that the AECB provide the Task Force with a risk assessment for each low-level radioactive waste accumulation in Ontario, in precise numerical terms.

All waste facilities presently subject to an AECB licence meet the requirements of that licence and in general keep effluent releases well below regulatory limits in accordance with the principle of limiting radiation exposure to "as low as reasonably achievable". The risk of any licensed facility is therefore something less than the risk associated with the radiation dose limitations in the Regulations.

We do not have precise numerical estimates of risk for each facility and in our opinion, such estimates by themselves would not be suitable for assigning priority for remedial action or disposal. However, we have attempted a qualitative ranking which might be used for this purpose. The ranking takes account of the following factors, some of which we include in our assessment for licensing and ongoing surveillance. There is no significance to the order in which they are presented.

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Canada

Waste Characteristics

- Bulk physical and chemical properties of the waste.
- Inventory of particular radionuclides and other contaminants and the longevity of the radioactive contaminants.
- Average specific activity (radioactivity per unit volume or weight). Care must be exercised in the use of this index inasmuch as "hot spots" may exist within the larger body of waste.
- Physical, chemical, biological and other processes taking place within the waste itself.

Characteristics of Storage Environment

- Geology, hydrology, meteorology and topography of the site.
- Existence/necessity of engineered works to contain the waste.
- Existence of natural geological barriers to movement of contaminants.
- Existence of physical, chemical, biological and other processes which inhibit movement of contaminants.
- Is the site adequately monitored?
- If monitoring is needed, can an efficacious monitoring program in fact be implemented?
- What is happening at the waste site (i.e., within the waste itself and within the surrounding environment) and how good is our understanding?
- If our present knowledge is inadequate, is it possible to acquire the required detail (may represent economic tradeoff with disposal of the waste)?
- Impact of the natural environment (physical, chemical, biological, geological, hydrological, meteorological) on the storage site, especially in the long term.
- Possibility of changes in the natural environmental processes over time (both beneficial as well as deleterious).

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- Are remedial measures necessary to ensure stability of the site and containment of the waste (may represent economic tradeoff with disposal of the waste)?

- Are adequate contingency plans in place to deal with the possibility of a gross breach of containment?

Separation of People and Waste

- How mobile are the contaminants within the waste itself?

- By what mechanism can the contaminants escape containment and what probability is attached to each of these possible mechanisms?

- Are any of these processes synergistic?

- What impact (radiological and otherwise) will escaping wastes have on man and the environment in both the short term and long term (i.e., do contaminants enter the general environment slowly and in acceptably dilute concentrations)?

- Can the general public gain access (inadvertently or otherwise) to the waste (i.e., the intrusion scenario)?

- Are institutional controls (e.g., monitoring, treatment of effluents, operation and maintenance of all systems, access control) necessary to ensure the continued separation of people and waste? This is the case at all waste storage sites now licensed by the AECB.

- If institutional controls are necessary, is there a reliable and stable organization which will accept responsibility for the waste for as long as it remains a hazard?

Because of these considerations, the AECB has a clear preference for long-term management (in effect, disposal) methods which do not rely on institutional controls for their success. However, the AECB does recognize that in certain situations, either for technical, social or economic reasons, it may be impracticable to avoid entirely the use of institutional controls. The decision to allow institutional controls must be made on a case-by-case basis. For cases involving long-lived waste, two principles should underlie the decision: in each case, to limit the extent to which institutional controls are invoked; and, to minimize the number of disposal initiatives which require institutional controls.

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The following ranking does not include those wastes on your list for which we have no responsibility or specific knowledge. The purpose of the ranking is to suggest priorities for action to achieve a more permanent solution for existing waste management problems. It should not be construed as a ranking of the current risk associated with these wastes.

High Priority

- Town of Port Hope
- Port Granby Waste Management Facility
- Abandoned Tailings

Medium Priority

- Welcome Waste Management Facility
- Chalk River Nuclear Laboratories

Low Priority

- Scarborough
- Masterloy Products Limited
- Exolon Company of Canada
- Chromasco Limited
- Norton Research Corporation
- Hawker Siddeley Canada Limited
- Haley Industries Limited
- Walker Brothers Quarries Limited
- Bruce Nuclear Power Development

Town of Port Hope

The waste accumulations in Port Hope contain long-lived radionuclides as well as significant quantities of non-radioactive contaminants. Many are situated in environmentally undesirable circumstances in close proximity to people. Contaminants are escaping and intrusion by people into the waste areas or into the wastes themselves is a real possibility. It is, in effect, an uncontrolled situation.

Port Granby Waste Management Facility

At the present time, this facility operates under an AECB licence. The risk presented by this waste is kept low by human intervention to treat the effluents, maintain the site, control access and monitor both the site and the effluents from it. The wastes (long-lived radionuclides and other contaminants, principally Arsenic) are stored in what is considered by today's standards to be environmentally unacceptable circumstances. Erosion of the bluffs along Lake Ontario is continuous and

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will eventually expose the wastes, allowing their rapid dispersion into the environment, likely within the next few decades.

Abandoned Tailings

At several places in the province, there are abandoned tailings which resulted from earlier uranium mining operations in the period 1950 - 60. These contain long-lived radionuclides and other contaminants such as heavy metals. Some deposits are located in "cottage country." In many cases, access is not restricted and there is no attempt to control airborne contamination and to treat liquid effluents. The possibility of intrusion is very real, given the attractive nature of the tailings as building materials.

Welcome Waste Management Facility

At the present time, this facility operates under an AECB licence. The wastes (long-lived radionuclides and other contaminants, principally Arsenic) are very similar physically to tailings. The manner in which they are stored, although acceptable at the time they were emplaced, would not be considered adequate by today's standards. However, in recent years, Eldorado Resources Limited has undertaken extensive remedial works at the facility which have greatly improved the situation. As in the case of Port Granby, the risk presented by these wastes is kept low by human intervention to treat the effluents, maintain the site, control access and monitor both the site and the effluents from it. Nevertheless, the wastes are long-lived and, in our opinion, there is a very real possibility of future human intrusion. We would therefore not consider the facility adequate in the long term.

Chalk River Nuclear Laboratories

CRNL is markedly different from the other accumulations of waste in the province. This is due primarily to the great variety of wastes that must be stored, wastes which encompass a wide range of physical, chemical and radiological properties. To cope with this, the operators of CRNL employ many different waste management practices. As well, there has been a distinct evolution in these waste management practices during the past forty years, in part as a result of CRNL's mandate to develop new waste management methods. As a consequence, some of the wastes are stored in circumstances which were acceptable at the time they were emplaced but which would not meet today's standards. CRNL is in the process of upgrading its treatment and storage methods and has expressed the intention to develop suitable on-site disposal technologies. The AECB considers these initiatives necessary for the long-term management of some of the CRNL waste and is closely monitoring the situation.

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Scarborough

The specific activity of the wastes is low, but the radionuclides are long-lived and the wastes are, in effect, uncontrolled and in close proximity to people. Because of this, we consider the situation unacceptable in the long term, even though the risk is low.

Masterloy Products Limited

The early operations of this company which produced radioactive waste were not regulated by the AECB. The radioactive waste was simply added to the slag heap. The AECB issued a Prescribed Substance Licence (PSL) in August 1978 when the production of radioactive waste recommenced, principally in order to control the disposition of the waste. In accordance with AECB instructions, the waste was drummed and stored on a concrete pad in a fenced area. The PSL was allowed to expire at the end of July 1982. Our knowledge of the waste management practices is therefore limited to this time interval. The bulk of the waste is in the slag pile. It contains long-lived radionuclides as well as other contaminants, principally Arsenic. Data with respect to what is happening within and below the slag pile are limited. The site is in a semi-rural area which will eventually be fully urbanized. There is always the possibility that the company could go out of business. Although the immediate risk is probably low, we consider the intermediate- and long-term risk unacceptable.

Exolon Company of Canada

This facility operated under a PSL from May 1978 until the end of January 1982 and our knowledge is limited to this time interval. Some waste remains buried on the site and the extent of soil contamination resulting from earlier practices is not known. Residential development is encroaching on the site. It is a situation very similar to Masterloy Products Limited but with a much smaller volume. Although the present risk is probably very low, we consider the intermediate- and long-term risk unacceptable.

Chromasco Limited

The AECB issued a PSL in February 1979 in order to ensure that the plant was cleaned up and that all wastes were consolidated in one place. The PSL was allowed to expire at the end of June 1985. Our knowledge of the waste management practices is limited to this time interval. If nothing has changed in the interim, we can assume the wastes continue to be well managed. The wastes contain long-lived radionuclides but the site is located in a

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relatively thinly populated area and the company appears to be in good health. We therefore conclude that the present risk is very low but we would prefer to see different measures taken in the long term.

Norton Research Corporation

This facility operated under a PSL from May 1979 until the end of January 1982. During that time, substantial changes occurred in the waste management practices used. We understand that the waste produced since 1980 is properly contained on site. Should circumstances warrant (e.g., demise of the company), the waste could be easily moved. Therefore, despite the fact that the waste contains long-lived radionuclides and the site is located in a relatively populous area, we do not think there is significant risk due to this accumulation at the present time. However, a long-term solution needs to be found.

Hawker Siddeley Canada Limited

The AECB issued a PSL in August 1980 in order to regulate the management of thorium-bearing wastes and it is still in effect. We are satisfied with present waste management practices and there seems to be little likelihood that the company will go out of business. The waste is situated in an urban environment, but it is stored in drums and could be easily moved. We are therefore convinced that the present risk due to this waste is very low. However, the radionuclides in the waste are very long-lived and a long-term solution is necessary.

Haley Industries Limited

Some operations of this company have been regulated by a PSL from May 1979 until the present. The purpose of the PSL, which will be allowed to expire very shortly, was to control the import and use of thorium-bearing magnesium alloys. The company has returned its remaining inventory of these alloys to its supplier and will no longer pursue that aspect of its operations. However, during the period from 1979 until the recent past, an unknown amount of thorium-contaminated, metal wastes was added to the slag pile. We are aware that the slag pile also received wastes of other kinds, arising from the foundry operations, which were contaminated with long-lived, naturally occurring radionuclides. The waste is located in a relatively thinly populated area and does not now represent a significant risk. However, the presence of long-lived radionuclides in the waste would suggest that a long-term solution should be examined.

Walker Brother Quarries Limited

This facility never operated under a licence from the AECB. However, all low-level radioactive waste received at the facility

was deposited in accordance with specific instructions from the AECB and the Ontario Ministry of the Environment and its emplacement conformed to good landfill practice. The radioactive waste, which had a low specific activity to begin with, was deposited in such a manner as to further dilute it by large volumes of other waste. The site is now in a rural area. The presence of other industrial waste, as well as the general circumstances of the deposit, would likely alert any future intruder to the existence of a waste accumulation requiring some care. We have concluded that this waste accumulation represents a very small risk, either at the present time or in the future.

Bruce Nuclear Power Development

The radionuclides which contaminate the waste stored at BNPD are short-lived. The management of these wastes is exemplary and they could conceivably remain where they are until they have completely decayed. In our opinion, they represent a minimal risk both now (assuming present management practices continue) and in the future.

Deloro, Phosphogypsum Industry

Because our knowledge of these sites is very limited, we are not prepared to comment upon them.

I trust that the foregoing will be of some assistance to the Task Force. Should you require clarification of any points or wish to discuss our conclusions, please do not hesitate to call us.

Yours truly,

W.D. Smythe
Director General

Appendix H

Assumptions for the determination of transport cost estimates to move the low-level radioactive wastes out of the Port Hope area

Appendix H

Assumptions for the determination of transport cost estimates to move the low-level radioactive wastes out of the Port Hope area

Transportation cost estimates were developed for a number of specific distances to move a total volume of 880,000 cubic metres of waste materials:

Road: 50 km, 100 km, 200 km, 500 km and 1000 km
Rail: 250 km, 500 km, 700 km, and 1200 km
Water: 1100 km

A number of conclusions were reached:

- the road mode is the preferred transport option for any disposal site located within 200 km of Port Hope;
- the water mode is the preferred transport option for any disposal site located in northern Ontario, close to the Great Lakes region (i.e., within 100 km of the destination dock facility);
- the rail mode is the preferred transport option for all other possible site locations.

Costs for the road mode

1 Transportation costs
- 50 km — $7 million
- 100 km — $12 million
- 200 km — $20 million

2 Steam cleaning costs
- $20,000 (estimated)

3 Waste digging costs
- assumed to be $20 per cubic metre for a total cost of $17.6 million

4 Waste site rehabilitation costs
- grading and landscaping – $5 million (assumed)

5 Infrastructure costs
- includes the cost of improving the roads before moving the wastes, and rehabilitation of roads after the movement of the waste material
- road mode is the most economical for distances up to 200 km from Port Hope. It is assumed that 10 percent (or 20 km) of new or improved roads will be required at the destination as follows:
  - 10 km each of new and improved roads
  - the cost of road construction is assumed to be $200,000 per kilometre; improvement and rehabilitation is assumed to be $80,000 per kilometre
- origin
  - construction of 1 km of road each in Port Granby and Welcome areas
  - improvement of 3 km of road from Welcome to regional roads
  - improvement of 10 km of road in Port Hope
  - improvement of 4 km of road from Port Granby to regional roads
- destination
  - construction of 10 km of roads
  - improvement of 10 km of roads
- Total infrastructure cost – **$4.4 million**

6 Contingency allowance
- 15 percent

7 **Total Costs for road mode – $39 – 54 million**

Costs for the rail mode

1 Transportation costs

• 250 km	$23 million
• 500 km	$34 million
• 700 km	$40 million
• 1200 km	$61 million
• Unloading	$ 0.5 million
• Loading	$ 0.5 million
• Trucking to Wesleyville	$ 2.0 million
• Trucking 50 km at destination	$ 7.0 million
Total transportation costs	**$ 33 – 70 million**

2 Steam cleaning costs
- $10,000 (estimated)

3 Waste digging costs
- assumed to be $20 per cubic metre for a total cost of $17.6 million

4 Waste site rehabilitation costs
- grading and landscaping – $5 million (assumed)

5 Infrastructure costs
- includes cost of improvement and rehabilitation of roads as well as construction of new rail siding
- assumes that the waste material will be moved 100 km from the main rail line as follows: over first 50 km, on new rail siding; 10 km of new road and 20 km of improved road; 20 km of road is assumed to be in good condition
- cost of new rail siding is assumed to be $300,000 per kilometre; road construction is $200,000 per kilometre; and road improvement and rehabilitation is $80,000 per kilometre
- assumes that the trains are loaded directly from trucks at Port Hope using a conveyor belt system and that at the destination there is a transfer station with a stockpile
- Origin
  - construction of 1 km of road in the Port Granby area
  - improvement of 1 km of road on the Wesleyville Ontario Hydro property
  - rehabilitation of 4 km of paved roads on Port Granby site
  - construction of 1 km of new road from Welcome to Wesleyville
  - rehabilitation of 10 km of paved roads from Welcome to Wesleyville
- Destination
  - no work required on 20 km of road
  - improvement of 20 km of road
  - construction of 50 km of rail siding
  - construction of 10 km of road

Total infrastructure costs – **$21.4 million**

6 Property rental fees for new road construction and rehabilitation costs on completion:
- $2,500 per month or $100,000 over 3 years

7 Costs of conveyor belt loading system
- $100,000 (assumed)

8 Costs of transfer station rental space
- $5,000 per month or $200,000 over 3 years

9 Contingency allowance
- 15 percent

10 **Total cost of the rail mode – $89 million – $132 million**

Costs for the water mode

1 Transportation costs

• 1100 km of distance (equates to 550 km of rail distance)	$16 million
• Loading	$ 0.8 million
• Lock fees	$ 0.5 million
• Trucking to docking facilities at source	$ 7.0 million
• Trucking 100 km to destination	$11.6 million
Total transportation costs	**$36 million**

2 Steam cleaning costs
- $5,000 (estimated)

3 Waste digging costs
- assumed to be $20 per cubic metre for a total cost of $17.6 million

4 Waste site rehabilitation costs
- grading and landscaping – $5 million

5 Infrastructure costs
- includes cost of improvement and rehabilitation of roads
- assumes that the waste material is moved 100 km from the dock facility as follows: over 25 km of new road and 50 km of improved road, and over 25 km of existing road that is in good condition
- assumes the cost of road construction to be $200,000 per km; the cost of road improvement and rehabilitation to be $80,000 per km; and the cost of new dock facilities to be $8 million
- assumes the vessel is loaded directly from the trucks at the docking facility using the conveyor belt system and that at the destination there is a stockpile at the transfer station
- Origin
  - construction of 1 km of road each in Port Granby and Welcome areas
  - improvement of 3 km of road from Welcome to Highway 401
  - improvement of 4 km of road from Port Granby to Highway 401
  - rehabilitation of 5 km of roads to the docking facilities
  - new dock facilities

- Destination – existing dock facility in good condition (no improvements required)
  - 25 km of roads in satisfactory condition
  - construction of 25 km of new road
  - improvement of 50 km of road

Total infrastructure costs – **$18.4 million**

6 Costs of conveyor belt loading system
- $100,000 (assumed)

7 Costs of transfer station space rental
- $5,000 per month or $200,000 over 3 years

8 Contingency allowance
- 15 percent

9 **Total cost for the water mode – $ 89 million**

Appendix I

References identified by numbers in text

Appendix I
References identified by numbers in the text

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Appendix J

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Appendix J
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